Pine Cone Prowl: Embodying a Flying Squirrel in Forest

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Figure 1: A: Player is climbing the tree, B: Player is gliding from a tree, C: Player is eating a food item

Abstract

Responding to escalating environmental challenges and a widening disconnection from nature, our project, Pine Cone Prowl, uses Virtual Reality (VR) to facilitate deeper connections between humans and nature through the life simulation of a Siberian flying squirrel. This VR experience improves on previous applications by offering advanced interactivity within a realistically simulated Finnish forest ecosystem. Players embody the squirrel and engage with its environment using abilities that mimic natural behaviors such as climbing and gliding, enhancing their understanding of and connection to the natural world. Our approach aims to allow users to experience firsthand the ecological roles and challenges faced by this species, thereby promoting human-nature connection.

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CCS Concepts

• **Human-centered computing** → **Virtual reality**; **Interaction design**.

Keywords

virtual reality, player experience, embodiment, embodied interaction squirrel, forest

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1 Introduction

In an era increasingly defined by pressing environmental challenges, the imperative for transformative societal responses has escalated dramatically. Research has identified multiple human and physical factors that impede public action on these urgent issues [14, 19]. Among these, psychological distance stands out as a critical barrier, where environmental problems are perceived as remote and abstract by individuals. This perception is further exacerbated by the diminishing time spent outdoors, driven by predominantly indoor

lifestyles [10, 11]. Addressing this disconnection is essential, as it impacts not only ecological health but also societal willingness to engage in proactive environmental actions.

The consequences of humanity's growing estrangement from nature cannot be overstated. This disconnection undermines individual well-being and weakens pro-environmental attitudes and behaviors [6, 9, 12, 13]. Regular exposure to natural environments offers significant psychological benefits—including improved mood, reduced stress, and enhanced cognitive function [4]. Thus, fostering a deeper connection with nature is essential, serving as a robust catalyst for enhancing environmental awareness and motivating conservation efforts. Empathy towards non-human entities plays a crucial role in this process, strengthening emotional engagement with environmental issues and making the challenges facing ecosystems more tangible and personally relevant. Additionally, research emphasizing the importance of mutuality, compassion, and relationality suggests that these emotional and social competencies are crucial for cultivating a sustainable and respectful relationship with our natural surroundings, leading to stronger conservation behaviors and a deeper ecological understanding [3].

Virtual Reality (VR) emerges as an innovative tool to mitigate the psychological distance from nature. Recent advancements in VR technology have introduced features that significantly enhance user immersion and interaction with the natural world, allowing individuals to experience life from the perspectives of various animals—such as climbing trees [15], flying, or swimming like a beaver [18]. These VR experiences, supported by realistic environmental interactions and sensory feedback, help users navigate diverse terrains and simulate animal behaviors, deepening empathy and connection with nature. Studies by Ahn et al. [1] and Bailenson [2] demonstrate how VR, especially through the embodiment of animals, strengthens human-nature connections by offering a first-hand experience of the world through the eyes of wildlife, thereby making environmental issues more tangible and personally relevant [20].

Building upon existing research, our submission, "Pine Cone Prowl," uses VR to deepen human-nature connections by embodying a Siberian flying squirrel. While VR research that investigates connections with nature through embodying animals typically utilizes realistic environments, it often falls short in terms of interactivity, providing limited scope for user engagement within these settings. Our project sets itself apart by not only placing users within a simulation of a Finnish forest, native to the Siberian flying squirrel but also enhancing the interactivity of the experience. This realistic setting is designed to provide a richer, more interactive encounter with nature. Users are not only observers but become active participants in the ecosystem, equipped with the unique abilities to climb and glide—activities that mirror the natural behaviors of the squirrel but are beyond human physical capabilities. By engaging with the forest from the perspective of a squirrel, "Pine Cone Prowl" aims to foster a profound connection with nature, encouraging users to adopt an alternative viewpoint on the forest's ecological role and its critical importance to the survival of species like the Siberian flying squirrel. This embodied experience is intended to enhance empathy towards the forest's flora and fauna, bridging the psychological distance some feel towards environmental issues and promoting a deeper appreciation of our interconnectedness with nature.

2 Related Work

2.1 Human-nature connections

Research into the human-nature connection underscores the significant psychological, emotional, and physical benefits derived from interactions with natural environments. Empirical studies by Bratman et al. [4] and Capaldi et al. [9] have demonstrated that exposure to nature significantly reduces stress, enhances mood, boosts cognitive function, and promotes overall well-being. Furthermore, research by Gifford and Nilsson [13] and Nisbet et al. [21] reveals that feeling a part of the natural world encourages behaviors that protect and preserve the environment, highlighting how interactions with wildlife, such as observing or symbolically embodying animals like the Siberian flying squirrel, play a role in fostering environmental conservation.

Studies such as those by Brügger et al. [7] have shown that people's appreciation for and feelings of interconnectedness with nature significantly influence their engagement in behaviors that benefit the environment, instilling a deep sense of responsibility towards its conservation. Such psychological bonds with nature can be strengthened through direct experiences in natural settings, environmental education, and innovative technologies like VR. VR, in particular, has demonstrated substantial potential for simulating realistic nature experiences, allowing users to interact with natural environments and wildlife in ways that might not be feasible in real life [1, 2].

Furthermore, Breves and Greussing [5] have highlighted how VR and Augmented Reality (AR) can effectively communicate environmental issues and foster a deeper connection with nature through immersive experiences. Their research suggests that incorporating elements of wildlife into these experiences makes environmental topics more engaging and personally relevant, thereby enhancing environmental awareness and promoting sustainable behaviors.

As society becomes increasingly urbanized and detached from natural environments, VR offers a novel approach to bridge this divide. By providing impactful experiences that simulate natural environments and include interactions with species like the Siberian flying squirrel, VR encourages a deeper understanding of our ecological systems. Such experiences are crucial for fostering the empathy and motivation necessary to undertake pro-environmental actions, contributing to increased environmental awareness and sustainability. Therefore, exploring VR applications that incorporate wildlife interactions emerges as a critical area of research and application, uniquely positioned to address contemporary environmental challenges effectively.

2.2 Embodying animals in VR

Current research on embodying animals in VR shows substantial impacts on participants' behaviors and attitudes towards environmental conservation. Ahn et al. [1] found that embodying non-human avatars, such as cows in VR, not only led to increased empathy towards animals but also a stronger inclination to engage in pro-environmental behaviors. This transformation is linked to VR's immersive capabilities that allow users to experience the world

from the perspective of another species, thereby deepening their emotional connection and ecological consciousness. Supporting this, Slater et al. [23] showed that VR's immersive environments significantly affect users' empathy, self-identity, perspective-taking, and pro-social behaviors, fostering a deeper concern for environmental issues. Further, Pimentel and Kalyanaraman [22] highlighted the critical role of immersion and avatar fidelity in VR, noting that highly realistic and interactive experiences enhance the embodiment effect, leading to profound attitudinal and behavioral changes. These studies underscore VR's potential as a transformative tool for promoting empathy and broader psychological and behavioral shifts essential for advancing environmental responsibility and proactive conservation efforts.

Building on this foundation, commercial VR applications such as Justin Beaver VR [18], Birdly [24], and GrowRilla VR [15] showcase the practical application of embodying animals in VR. Justin Beaver VR immerses users in the life of a beaver, engaging them in ecologically relevant activities such as dam building and habitat exploration to enhance understanding of beaver ecology and promote environmental consciousness. Birdly offers a flight simulation that provides an educational exploration of various bird species, adding a therapeutic dimension through the sensation of flight. Meanwhile, GrowRilla VR introduces a novel gameplay dynamic, where players start as small gorillas and grow by consuming their environment. This unique approach incorporates elements of humor, adventure, and strategy, offering a comprehensive educational experience that deepens players' understanding of gorilla behavior and the ecological challenges they face, thus fostering a richer appreciation for wildlife and natural habitats through VR. Collectively, these applications illustrate how VR can bridge entertainment with educational and conservation efforts, serving as powerful tools for fostering deeper environmental engagement and understanding.

Building on the successful integration of VR in environmental education and interaction, our game seeks to further expand and refine these experiences. It enhances the realistic portrayals and interactivity offered by predecessors like Justin Beaver VR, Birdly, and GrowRilla VR, by providing an even more immersive simulation of wildlife behaviors and habitats. It allows players to engage more deeply with the environment as a Siberian flying squirrel, emphasizing the unique dual abilities to climb and glide through a crafted forest ecosystem. This aims to increase the educational value by highlighting specific ecological roles and challenges faced by the species and enhances empathy and environmental awareness through direct interaction and problem-solving. By focusing on these species-specific experiences, our game aims to foster a nuanced understanding of wildlife and their habitats, encouraging players to consider conservation issues from new perspectives and inspiring more informed environmental actions in the real world.

3 Game Design Overview

3.1 Goals and Audience

The primary objective of Pine Cone Prowl is to provide users with a profoundly immersive experience from the perspective of a Siberian flying squirrel. This entails engaging in activities characteristic of the species, such as scavenging for food and gliding between trees. By adopting the vantage point of a smaller-bodied creature, the application shifts the user's interaction with the environment, altering the meanings and affordances traditionally associated with the forest landscape. Such a perspective not only enables movement through the forest in ways otherwise impossible for humans but also enhances perceptual sensitivity to aspects of the forest that typically remain unnoticed.

This immersive VR experience fundamentally transforms the user's understanding of the forest. Rather than viewing it merely as a recreational space visited occasionally by humans, the application redefines it as a vital habitat—the primary living space and an all-encompassing world for the Siberian flying squirrel. By embodying this role, users gain a intimate view of the forest, fostering a deep empathy towards wildlife and an appreciation of the forest's integral role in the survival of its inhabitants. This shift in perspective is designed to resonate especially with individuals who are detached from nature and typically unengaged in environmentally conscious practices. The goal is to foster a connection with nature and bridge the gap between human experience and animal exigencies. The insights garnered from this prototype will contribute to exploring how users internalize and react to their embodied experiences in VR, with the outcomes expected to inform further enhancements of the application.

3.2 Design Process

The development of Pine Cone Prowl presented in this document forms a crucial part of the doctoral research project undertaken by the first author, aimed at exploring how VR embodied experiences within forest settings can enhance human-nature connections. During the initial phase of the research, a comprehensive literature review was conducted, focusing on the use of virtual and augmented reality technologies in promoting environmental sustainability. This review facilitated the identification of pertinent findings and knowledge gaps within the existing body of research, which in turn informed the design objectives and considerations for the VR prototype.

The concept of designing embodied experiences that enable users to perceive a Finnish forest from unconventional perspectives and varying heights emerged from insights gained from prior VR studies. These studies demonstrated that experiencing different heights can significantly influence the type of learning that occurs [16, 17]. The diversity in size and behavior of forest animals offers multiple modalities for these experiences, thus providing a flexible platform to present varied forest perspectives distinctly from human viewpoints. This approach is bolstered by further research which indicates that embodying animals in VR can effectively foster a connection with nature [1, 20, 22].

To determine which animals would be featured in the VR experience, a matrix was created categorizing different native Finnish animals and the unique perspectives or experiences they could offer to users. For the initial prototype, the decision was made to start with a simple theme and basic interactions as a proof of concept, which could be later expanded into a more comprehensive game. This selection process favored animals that interact significantly with trees in the forest, focusing on species native to Finland to simplify the design process by enabling direct observation and visualization within local forest environments.

The choice of the Siberian flying squirrel as the subject for the first prototype was driven by the unique opportunities their size and arboreal abilities offer. Their capability to climb and glide from tree to tree provides an experiential perspective that is drastically different from the human physical experience, thus offering profound insights into the forest ecosystem from an entirely new vantage point.

3.3 Development

The development of our prototype was achieved using Unreal Engine 5.2, a sophisticated platform provided by Epic Games. This engine facilitated the integration of Blueprint Visual Scripting, which allowed for efficient and effective logic and programming implementation. To construct a rich and immersive natural environment, vegetation models such as trees and grass were created using SpeedTree, a dedicated tool for vegetation modeling within the gaming industry. The anatomical features of the Siberian flying squirrel, particularly the hands, were modeled and animated in Maya, with reference to photographs to ensure anatomical accuracy.

In terms of visual assets, textures and materials were primarily sourced from Quixel Megascans, which offers an extensive library of photorealistic assets that significantly enhanced the visual fidelity of the environment. When specific textures were unavailable, Adobe Photoshop was employed to create custom textures that were harmoniously integrated into the existing visual framework.

The prototype was designed to ensure broad compatibility across a variety of VR head-mounted displays (HMDs) using OpenXR. This platform-agnostic application programming interface (API) supports the development of extended reality (XR) applications, facilitating access to our VR experience across diverse hardware configurations. The interaction within the prototype was engineered to leverage the positional tracking capabilities of VR controllers, central to delivering a fully embodied user experience.

Interaction design within the application was crafted to replicate the movements and environmental interactions of the Siberian flying squirrel as closely as possible while accommodating the ergonomic realities of human users. For instance, the prototype includes an eating mechanism that allows users to pick up and consume items like pine cones and seeds using a simplified single-handed approach, despite the dual-handed feeding behavior observed in the actual squirrels, to minimize user confusion and enhance gameplay fluidity.

Navigation within the virtual environment can be accomplished by physically walking and turning, or alternatively, using thumb sticks for movement. Climbing mechanics are intuitive: users approach a tree trunk and engage a trigger on the controller to simulate grasping the bark, then alternate arm movements to ascend by pulling down, mimicking the action of climbing. To accommodate the scale and movement dynamics of the small-bodied Siberian flying squirrel, a feature was incorporated allowing users to 'launch' themselves upward for more rapid vertical movement by quickly grabbing higher on the trunk and releasing.

Furthermore, the prototype introduces the iconic gliding ability of the Siberian flying squirrel. Although a complete anatomical model including the skin pouches was not developed, the essential body positioning and movement for gliding were simulated. Users initiate a glide by adopting a T-pose with arms extended, stepping off a branch to navigate through the air toward desired destinations within the forest, such as a branch with appealing catkins. These interactions are designed to enhance the overall sense of presence and engagement within the virtual environment, offering users a deeply immersive experience that connects them more profoundly with the natural world.

4 Game Novelty

While previous VR applications have enabled users to embody animals and explore their perspectives, Pine Cone Prowl seeks to expand on these experiences by integrating a broader range of ecological interactions and survival behaviors into its gameplay. The game is designed to allow players to engage in activities such as climbing trees, gliding between branches, and foraging for food within a detailed, interactive ecosystem, aligning with research that highlights the importance of interactive environments in enhancing ecological understanding [1].

This approach seeks to provide a more holistic and ecologically relevant experience by emphasizing not only the sensory and motor aspects of animal embodiment but also the complex environmental interactions that are crucial for species survival. The game creates a realistic simulation of a Finnish forest, offering players an experience that reflects the intricate balance required to thrive as a small, arboreal mammal. By focusing on these specific survival behaviors, the game highlights the critical ecological roles of lesser-known species like the Siberian flying squirrel, offering players a novel perspective on biodiversity and conservation.

A key goal of Pine Cone Prowl is to immerse players in the nuanced challenges faced by the Siberian flying squirrel, an experience that fosters empathy and understanding of non-human experiences. By allowing players to navigate the forest from the perspective of this small mammal, the game shifts the traditional human-centric view of nature to one that is more inclusive of other species' experiences. This shift in perspective contributes to a more profound emotional connection to the natural world, which can lead to more engaged and responsible environmental behaviors [3].

Furthermore, Pine Cone Prowl challenges players to consider the broader implications of their actions on the environment and the habitats of animals such as the Siberian flying squirrel, thereby broadening the scope of biodiversity education. The game encourages reflection on the impacts of habitat degradation and species loss, drawing attention to the often-overlooked exigencies of wildlife. By fostering a deeper understanding of these issues through direct, interactive engagement, Pine Cone Prowl aims to inspire more thoughtful and informed approaches to conservation, contributing meaningfully to both environmental education and virtual reality gaming.

5 Conclusion

Pine Cone Prowl presents a unique Virtual Reality experience designed to strengthen the human-nature connection by placing users in the role of a Siberian flying squirrel. Through the simulation of natural behaviors such as climbing trees, gliding between branches, and foraging for food, the game offers an immersive experience within a realistic Finnish forest environment. This approach allows

users to gain new insights into the ecological roles and survival strategies of forest inhabitants, fostering a deeper understanding of these ecosystems.

The immersive nature of Pine Cone Prowl is intended to cultivate empathy towards wildlife, enhancing the user's perception of the forest as a vital habitat rather than just a recreational space. By embodying the perspective of a non-human species, players are encouraged to engage more meaningfully with the environment, which can help bridge the gap between abstract environmental awareness and tangible, empathetic engagement. This direct experience aims to motivate users to adopt more environmentally responsible behaviors, highlighting the interconnectedness of all life within the forest ecosystem.

The insights gained from interacting with this VR experience have the potential to make a significant contribution to environmental conservation efforts. By influencing how individuals perceive and interact with natural environments, Pine Cone Prowl supports the development of more sustainable behaviors. This project lays a foundation for further research into the impact of immersive experiences on environmental attitudes and behaviors, promoting a more profound ecological understanding and a commitment to sustainable living.

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