

***Farmooo*, a Virtual Reality Farm Simulation Game Designed for Cancer Pediatric Patients to Distract their Pain during Chemotherapy Treatment**

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Abstract

For nearly two decades, immersive Virtual Reality (VR) has been used as a form of pain distraction and management for acute, chronic and cancer pain. Moreover, in numerous studies, VR games and virtual environments (VEs) have been shown to be effective during chemotherapy treatment for reducing pain and anxiety. However, amongst all of these research studies, few have focused on pediatric patients who are undergoing chemotherapy treatment. Furthermore, most of the research studies used commercial video games which were neither specifically tailored for immersive VR environments nor for pediatric patients. Therefore, to understand pediatric oncology patients' preferences about using specific VR games during their treatment, we developed a VR farm simulation game called Farmooo using an Oculus Rift DK2 and a Leap Motion sensor. In this paper, we introduce the design inspirations, rationale and procedures, as well as the game mechanics of the VR game we specifically built for this application, entitled Farmooo. Our goal was to design and test a VR pain distraction game that will enable our future participants to immerse themselves in the game world and thereby help to distract them from their pain and discomfort during and after chemotherapy. Results from our pilot Focus Group study with pediatric outpatients showed the great potential of the VR game, Farmooo, as a distraction tool.

Keywords

Virtual Reality, Serious Game, Farm Simulation, Pediatric Oncology Patients, Pain Distraction, Chemotherapy, Game Design and Mechanics.

Introduction

Since the 1990s, immersive Virtual Reality (VR) has been applied in a variety of clinical settings as a technologically-mediated form of pain distraction or management, physical rehabilitation, and psychiatric disorder treatments [1]. For cancer patients, VR is a promising tool for cognitive distraction and psychological support [2]. In oncological contexts, VR has been used during chemotherapy infusions [3], during painful oncological treatment procedures [4], and to decrease distress levels while patients are hospitalized [5]. A systematic review of the effective use of VR in the biomedical field included 19 studies of VR in cancer treatments [2]. An overall analysis of the systematic review also showed that VR seems to have the best efficacy during chemotherapy. Although these studies varied greatly in setting and design, the researchers' review results found that VR improved patients' emotional well-being, diminished cancer-related psychological symptoms, and included different types of settings (i.e., during chemotherapy, during pain procedures, during hospitalization) [2]. Specifically, the findings

suggested benefits of using virtual reality as a distractor, including lower pain and anxiety ratings, as well as reduce pulse rate [6].

However, only a few of these research studies addressed the effect of VR on pediatric oncology patients during their cancer treatment or any specific needs they may have. Moreover, this subset of patients showed promising results regarding pain distraction and relief of distress [7].

Many studies used generic commercial computer video games which were neither designed specifically for immersive VR technology, nor as an immersive experience that might help distract pediatric oncology patients from their pain. More recent research also suggested that the powerful and transformative nature of many VR experiences may also pose some risks and should be utilized with caution for distracting pediatric patients from their cancer pain [8].

Cancer patients require more care compared to patients with other illnesses, in part because of the physical and psychosocial uncertainty and impacts of their disease and treatment during their teens — a well-known difficult time of life. This complexity means more care must be taken in the design of virtual environments, from “content” to technological issues. After we decided that a VR game would be appropriate in this context, a goal became gamifying the pain distraction experience for teen cancer patients who undergo chemotherapy treatments, and who experience boredom and discomfort during or after the treatment process as well.

The resulting VR game aims to use state-of-the-art VR technology (an Oculus Rift Head-Mounted Display and Leap Motion sensor or Wii remote controller) to evaluate the efficacy and potential viability of such games targeted for pediatric oncology settings. The concept of a farm symbolizes hope and growth, and provides everyday motivation to maintain a farm with rewarding achievements. Additionally, the concept is based on successful simulation games such as *FarmVille* [9] and *SimCity* [10], and builds on what is known about VR and pain distraction. The immersive, simulated environment gamifies the pain distraction experience for teen cancer patients who are undergoing chemotherapy treatment. While pain distraction is the primary goal of *Farmooo*, it was also designed to alleviate boredom and discomfort throughout treatment processes by employing game mechanics that enable more fast-paced and highly interactive gameplay, in addition to the more casual ways players can explore the virtual environment.

In this paper, we focus on the game design of our VR game *Farmooo* for pain distraction during chemotherapy, including its game mechanics, dynamics, and aesthetics. Furthermore, we discuss the reasons and motivations of our design decisions and our practical considerations of using VR games in pediatric care.

The Game, *Farmooo*

In this section, we introduce the game design purposes, decisions and inspirations of *Farmooo*, including game mechanics, dynamics, and aesthetics.

Design Purpose and Motivation of *Farmooo*

Farmooo is an immersive virtual reality (VR) farm simulation game designed to help distract teenage cancer patients from pain during their chemotherapy treatments. Since games are usually targeted for entertainment purposes and because studies of medical uses of VR revolve more around adults, we re-examined game design principles when creating this VR game.

While it is unclear what the exact mechanism is to explain why pain distraction works, it is thought to work as a way to bring all of one's attentive capacity to the forefront of cognition, which in allows pain to be relegated to the background of attention. For example, while playing in a hectic virtual environment, all focus in the brain will be directed towards gameplay and that time will pass by very quickly when one is having fun.

We expect that the implicit metaphor of life can spark hope in teen cancer patients. Using this concept, the game has been tailored for a special need: to offer benefits and meaningful values for young patients and their caregivers. Hence, the idea is to both attempt to implement distractive gameplay elements while, at the same time, to offer a way for patients to look forward to the future by growing and harvesting plants in their farm.

The Gears

The game was designed to work with an Oculus Rift (OR) Head-Mounted Display (HMD), combined with either a Leap Motion sensor (as shown in Figure 1) or a Wii controller. Opposed to conventional video games, where players stare at a flat screen from a distance to conduct gameplay, the stereoscopic view afforded by the HMD enables players to feel immersed in the tailored three-dimensional virtual farm world. In addition, rather than using a mouse and keyboard or game player controller as input devices, *Farmooo* uses a Leap Motion sensor mounted on the front of the OR which allows players to employ hand gestures. An optional Wii controller can be used during times when the player cannot physically use both hands or when their hands are preoccupied by medical procedures. Both devices are considered to be more "natural user interfaces" than the keyboard and mouse or game controller because they allow the players to interact with the VR game more directly, using one or both of their hands.



Figure 1. A player interacting with *Farmooo* VR environment using OR HMD and Leap Motion.

Game Mechanics, Dynamics and Aesthetics

In this section, we introduce the game mechanics, dynamics, and aesthetics. Each mechanic has a metaphor behind it that implies an aspect of life and hope for pediatric cancer patients.

Core Mechanics: Growing Crops

As specified in the diagram below, the main mechanic of the game is to farm (Figure 2). Farming includes planting carrot seeds, watering the plants and then harvesting them (Figure 3, bottom middle image). By conducting the tasks specified, players can gain achievement badges depending on the amount of plants they grow. For instance, as a beginner, players will have a rookie badge that hangs inside the farmhouse. Eventually, as players harvest more and more carrots, their rank will rise to the maximum rank of Advanced Farmer.

Moreover, by implementing metaphorical game mechanisms, the game designers intend to offer to teen cancer patients the experiences of companionship (via a companion cow), as well as hope and future prospects from planting, growing and harvesting their plants on their own farm over time. Furthermore, the presence of the companion allows players to understand that they are not alone. Importantly, these farming tasks aim to distract patients from their pain by providing an immersive environment that focuses much of their attention as well as cognitive and perceptual capacities on tasks. Therefore, the VR game was conceived with two ideas of time. First, during gameplay, *Farmooo* offers immediate pain distraction — the plants grow at an accelerated rate in order to enable a player to plant, water, tend and harvest in one sitting. Second, *Farmooo* is also designed to encourage players to return to their farm many times over longer periods of time.

To accompany the core mechanics in the core loop, other elements were designed to add challenges and fun, known as "smart depth." These are represented in Figure 2 (left) in grey text. For instance, to plant carrots, a seed needs to be dropped. Eventually, the soil will get dry and the player will need to water them. When the time is right (according to gestural "triggers"), carrots will grow and the player will need to harvest them to gain rewards and become a higher ranked farmer.

The objective of the primary gameplay consists of executing the core loop tasks. These include growing a large amount of carrots. Additionally, players can try to plant their crops across the entire field and grow them in a quick manner. Therefore, in such fast-paced periods of the game, the gameplay mechanics afford patients distraction from their pain and boredom.



Figure 2. Left: Game mechanics flow chart: growing carrots; Right: Inside the farmhouse, with beginner rookie badge.

Secondary Mechanics: Petting A Cow and Exploring the Farm

The secondary objective of the game allows patients to casually stroll through and explore the farm environment. For instance, they can walk around the field or look above the sky (occupied by clouds, as well as an occasional fly-by of a paper airplane and crows), pet the companion cow and observe their achievements in the farmhouse. They can also go up to the windmill/watch tower to see an overview of the land (Figure 3, bottom left image). A cow companion was designed to come when called according to her mood and players can also pet it (Figure 3, bottom right image). The mechanic of the cow further enhances the notion of companionship, where perceived responsiveness is key to one's emotional security [11]. This virtual world is not just static graphics, but alive and responding to the players. Hence, this alternate approach results in a slower-pace period where environmental elements of bird sounds and airplanes — or simply using exploration as a means of meditation or “going somewhere else” — can potentially distract patients from their pain during procedures and from the boredom and social isolation during hospital stays. Figure 3 (top image) shows a view of the overall terrain in gameplay. This screenshot demonstrates a bird's-eye view of the actual game.

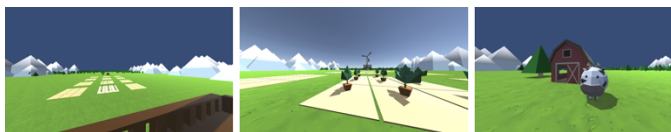
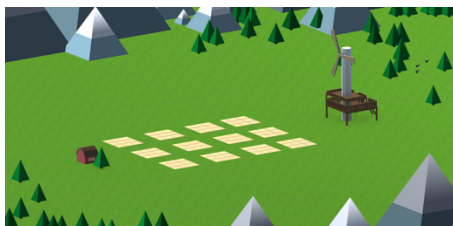


Figure 3. Screenshots from the *Farmooo* VR Game (from top to bottom, left to right): bird's-eye view of the terrain; walking around the environment, climbing the tower; planting crops; and petting a cow.

Game Aesthetics: Low-Poly Art Style

The game designers adopted a low-polygon aesthetic for the game, as shown in the above screenshots. First, the low polygon count ensures that the performance remains superb, which means that players are far less likely to experience “lag” — a major reason for nausea in VR games. Hence, the contributions made can allow better immersion to distract one in a medical setting. Secondly, the abstract low-poly style provides more imaginative space and inspirations for the teens as they explore and immerse themselves in a fantasy world. As one patient said during the Focus Group, “I can grow what I want — if someone else thinks it's carrots, great.” In short, it is thought that lower poly approaches enable players to more imaginatively construct what they are seeing, somewhat akin to the difference between reading a book and seeing a movie.

Interactions and Navigations

To interact with the game world, there are certain interaction influences. For example, there are game elements (such as the need

to grow and harvest carrots) to manipulate, as well as capabilities, such as the ability to walk around and explore the world. The game mechanics are aimed to distract patients who are bored or feeling pain during and/or after chemotherapy treatments. However, there are no avatars used in this game; in a sense, the player becomes the avatar themselves as they are located inside the game world from a first-person perspective.

Farmooo is also adaptive in different situations, based on the target audience of teenage cancer patients. Due to the dynamics in a player's health during and after treatments, it was important for the game to adapt to both in- and off-bed situations. Therefore, in terms of inputs, there is a gesture mode and a controller mode. The former depicts a player's hand as a transparent hand, a visual cue to making gestural inputs; the latter is accomplished by pressing buttons on a Wii remote controller. Of the two input methods, the gesture-based hand version is for patients who can move freely and are out of bed, while the button-pressing is for those who are in-bed (so the patients do not necessarily need to get up or to get out of bed if it is not ideal for them at the time). Hence, the interaction model provides game mechanic interactions.

Pilot Focus Group with Outpatients

To understand the potential of using this VR game in clinical settings, a 2.25-hour Focus Group was conducted with 6 Outpatients. Outpatients were selected for their comparatively risk-free potential. The study session consisted of three sections; a presentation about the design of *Farmooo*, then the game was tested by each patient, and lastly a post-test questionnaire and a discussion circle. The main findings from the coded questionnaires were then organized into four consistent themes: virtual reality content, gameplay, VR input and interaction controls and drawbacks.

Participants expressed deep appreciation that a VR game was built specifically for them. However, some concerns on interaction arose, including mobility when a patient is attached to an IV, those with cold hands decreased accuracy for gesture detection and a need for more challenging gameplay. Most of the participants enjoyed the form of the game, particularly the experience of feeling immersed in the three-dimensional, interactive VR environment. They all showed high interest and positive attitudes about using a more robust VR game if they were still undergoing chemotherapy. Notably, most participants reported that they would like to be notified after additional game content is added to *Farmooo*, and would like to be the first to try out the upgraded and polished game.

Conclusion

In summary, the process of creating a VR game targeted for a specific group — teens undergoing chemotherapy — in a specific medical domain provided numerous learning opportunities and challenges. In this paper, we introduced a VR farm simulation game entitled *Farmooo* designed for the Oculus Rift DK2 and Leap Motion sensor. We then described the game mechanics, dynamics and aesthetics used in *Farmooo*, and the decisions behind them. A prototype of *Farmooo* was presented to a Focus Group comprised of former cancer patients. Their feedback will help us refine the design of *Farmooo* in its next iteration. We hope the design decisions made in this game, along with the rationale behind them and the resulting prototype can contribute to other serious VR games or research for similar purposes

Results gleaned from the Focus Group provide a basis for better understanding the specific needs and attitudes of teens who

may use VR games like *Farmooo* as a means of distraction during chemotherapy.

The researchers intend to raise additional funding to enhance the current VR game according to these research findings and suggestions from the Outpatients participants. They will also work with BC Children's Hospital and other hospitals that have expressed interest to ensure that it can become accessible for patients in a sustainable way.

In future work, we will be able to test and evaluate the refined game with actual pediatric cancer patients, and disseminate that version of *Farmooo* in the medical field for teen oncology patients.

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Author Biography

Janice Ng received her BA in Interactive Arts and Technology, in the Design concentration, from Simon Fraser University (2016) and was awarded one of Surrey's Top 25 Under 25 (2017). She has interned at various places such as IBM and now works for the City of Surrey as a User Experience Designer. Her design specialties aim to bridge the gaps of human behaviours, art, and technology to craft delightful experiences for people to interact with.

Henry Lo received his Bachelor of Science in Interactive Systems at the School of Interactive Arts and Technology from Simon Fraser University (2016) and awarded as one of Surrey's Top 25 Under 25 (2017). Since then he has worked in the Front End team at Playgon Interactive Inc. (previously Virtuosol Software Inc.). His work involves bringing immersive Las Vegas Casino experiences to players across the Internet.

Xin Tong received her MSc from SIAT and is pursuing her PhD degree at the Pain Studies Lab. She holds a Bachelor of Engineering degree from Beijing University of Posts and Telecommunications. Xin's MSc thesis is about facilitating motivation and self-reflection of physical activity data using gamification strategies. Her research interests are designing technology for healthcare and patients, including Virtual Reality, digital games and wearables.

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Weina Jin is a PhD student from the School of Interactive Arts and Technology at Simon Fraser University. She received her Doctor of Medicine (MD) degree in Neurology from Peking University, and did her neurological residency at Peking University First Hospital. Her research interests are health-related HCI, VR and serious games.