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Survival On Mars - A VR Experience

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Abstract It has been a long time since the colonization of Mars was only a point of discussion in science fiction. Today, with the omnipresent topic of the climate change, some people picture Mars as a viable alternative to Earth. This paper describes the major challenges of living on Mars, and explains the implementation of a virtual reality experience on the red planet, built upon those challenges. The interactive simulation confronts people with the potential problems on Mars, and this paper discusses and evaluates the impact on the players opinions as well as their reactions. Results show, that the VR experience affects peoples perception of Mars, however the general desire to settle Mars remains.

Keywords: Virtual Reality · Survival on Mars · Wrong Assumptions

1 Introduction

In recent years, the colonization of Mars has reached popular culture to an extent where even SpaceX CEO Elon Musk has frequently addressed this topic through interviews and his social media channels [10, 4]. But building a liveable and enjoyable habitat on the red planet is very difficult. Conditions on Mars are hostile, and humans can only live there with massive restrictions. The aim of the work is to build a virtual reality experience which demonstrates a typical day on Mars in an entertaining but also informative way. The goal is then to confront the player with some of the problems a potential marsian inhabitant would have, and evaluate the results of the players reactions. Especailly, we answer the following questions:

1. What are the major problems of living on Mars?
2. How can you implement those problems in an interactive Virtual Reality experience?
3. How do people perceive living on Mars before and after the experience?

2 Related Work

Virtual reality is now in its heyday, as big publishers slowly begin to deliver significant titles. At least since the introduction of virtual reality for the smart-phone it has reached big popularity and became more affordable for the end consumer. Due to the high immersion VR provides, many game developers try

to create “worlds” which users cannot explore in real life. Since the surface of Mars is still untouched by humans it makes up for a perfect and exciting setting for developers as well as for the players.

One of the more detailed implementations of a VR-Experience on Mars is “Mars 2030” [5]. It was created by Fusion Media Group in cooperation with NASA and let’s you explore an accurately-mapped terrain from satellite footage. Not only can you discover the surface of Mars by foot but also with a rover. The Virtual Astronaut [14] is a tool which can create a virtual 3D environment. It is interactive and is built on the Unity engine [11]. A first prototype was created for the Santa Maria Crater on Mars. Scientists can use this tool for example to measure distances on the surface in an very intuitive way. Mental health of the crew members during long term space missions is very important. In [8], the authors examined the use of virtual reality to help sustain mental health during simulated typical situations which are usual on NASA missions. Their results show that due to the capabilities VR provides, a good preparation for the Astronauts can be achieved, but there is still more research in this field necessary. Besides the work mentioned above, it is worth mentioning that there are many 360 videos on the internet which also provide impressive immersion. Since nearly every phone nowadays support 360 video playback function, many people can benefit of this feature.

3 Conditions on Mars

Due to elaborated costs, it would not be possible to transport all resources to Mars from Earth. This means astronauts have to rely on in situ resource utilization (ISRU). This leads to many complications, as the Mars has much different environmental parameters than earth. To keep the virtual reality experience focused on the essential things and the message simple, it concentrates on 6 major conditions - respectively problems as detailed below.

Breathing on Mars: The surface pressure on Mars lies between 5 to 11 hPa which is about 1% compared to earths atmospheric pressure [12]. That means the human body has to be protected by a pressure suit, otherwise the liquids would boil away within minutes. Oxygen has to be extracted from the atmospheric carbon dioxide or from the chemical hazard Perchlorate found in Marsian soil.

Producing Water: Against common belief there is plenty of water on Mars, though it mostly exists as ice. Some of it exists as vapor in the atmosphere [2]. Because of the low atmospheric pressure, water on Mars only comes in those two forms. That is why melting the ice would lead to vaporizing the water instantly.

Toxic Soil: Due to the high concentration of Perchlorate the martian soil is toxic [13]. This makes the process of growing crops extremely difficult. A lot of research takes place in this field [1].

Radiation: In contrast to earth, Mars unfortunately does not provide a magnetic field or a dense atmosphere that could protect the planet from space radi-

ation. The International Space Station (ISS) also is not protected by an atmosphere but still is in the range of the earth's magnetosphere. This is why radiation exposure on Mars is two to three times higher than on the International Space Station.

Extreme Temperatures: With a median temperature of -60° the surface of the red planet is much colder than the earth's [12]. This does not only mean that home bases and green houses will have to have a very good isolation and heating, but also that machines and robots have to cope with that - just like Curiosity uses plutonium not only to power itself [6].

Generating Power: One way of producing enough energy for survival is to use solar power, like it was used for example on the Mars Rover "Opportunity". Solar power is relatively easy to install. But there are several problems [3], including smaller yield and dust storms. Another solution would be to use plutonium-238 to produce electricity, which is used by the Mars Rover "Curiosity" [6].

4 Survival on Mars - A VR Experience

In order to convey the fact that living on Mars is probably very different to what many people think we implemented the VR experience "Survival on Mars".

As VR headset we used the Oculus Quest. It comes with two controllers, one for each hand. The controllers provide one joystick, two buttons, one trigger and one "grip" button. The experience was developed with the game engine "Unity" version 2019.2.13f1 [11]. All sounds either got downloaded from the royalty free music website soundbible.com [9] or are self-made. In the game there is also a robot voice which was generated on a website called onlinegenerator.com [7] and then captured from there.

4.1 Main Story Line

To let the player dive into the scenario and leave an impression, it was necessary to create a story similar structured like a movie, encompassing an introduction, a confrontation, and a climax.

The story begins on the main menu screen, where the player learns that a couple of months have passed since the first humans successfully landed on Mars. They live under the surface to keep safe from radiation. Regularly though, one of the astronauts has to get back up on to the surface and check the status there. The astronaut has to analyze the plants in the green house for toxic or non toxic plants, he has to collect stone probes that will get analyzed for water traces, and he has to make sure that the electricity is working.

The player slips into the role of one of those astronauts and the game starts. He wakes up in the main station, a base which provides several resources that the player will need later on. The astronaut has to go outside, this is the moment the player first experiences to be on the surface of Mars. He sees and hears a little breeze, and feels the harshness of the red planet. During the whole operation

the player always has to have an eye on his left HUD, where he sees his oxygen and radiation status. If the oxygen runs out, the game is over, if the radiation is too high, the game is also over. He gets prompted the task to go to the green house and analyze the plants. The player walks in there and sees many different plants in there. On the other end of the room, there is a “Plant Analyzer”, which allows the astronaut to check whether a plant is toxic or edible. He has to put the plants on there, then the analyzing process starts. After he finds an edible plant, he has to bring it to the main station. In the main station there is a “Radiation Defuser”, which brings down the players radiation level.

After this, the player gets the task to go to the drilling station where he has to collect multiple stone probes. He does that and again has to return back to the main station.

Suddenly a voice tells him that he quickly has to get the power back on because the green house is in danger to freeze without heating. He rushes there and manages to get the power back on. A voice tells him that a sand storm is on the way and he has to get back to the main station as fast as possible. The player tries to get there. As the sand storm reaches the players location, he notices a drastic oxygen loss. This is where the game ends.

4.2 Description of Scenes

Title Screen: The first thing the player sees after the “Splash Screen” with the Unity Logo is the Title Screen. It features a great view of the red planet with the title “Survival On Mars” and a Start button. It is also the first time the player sees his “virtual hands”. To navigate through this menu and press buttons, there is a ray attached to the right hand. It points from the hand to the canvas which holds the button and the text. After pressing start, while the next scene gets loaded in the background, there is a brief introduction to the backstory (cf. Section 4.1). Then the player can finally start the main scene.

Main Scene: After the title screen the player wakes up in the Main Base of the Main Scene. He gets prompted tasks to his HUD and explores the main compound (cf. Figure 4) consisting of the following sites:

- **The Green House:** (cf. Figure 1). The green house is a lab where different kinds of plants are cultured. A big problem of growing food on Mars, is that the soil is toxic due to Perchlorate [13]. This is why the lab features a “Plant Analyzer” which analyzes if plants are toxic or not.
- **The Drilling Site:** (cf. Figure 2). The drilling site is a place where a big drilling machine mines martian rocks to look for potential water resources.
- **The Solar Panels:** (cf. Figure 3). The solar panels are responsible for the power supply of the whole mission.

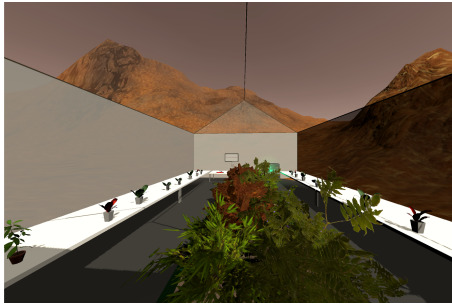


Figure 1. Inside the Green House

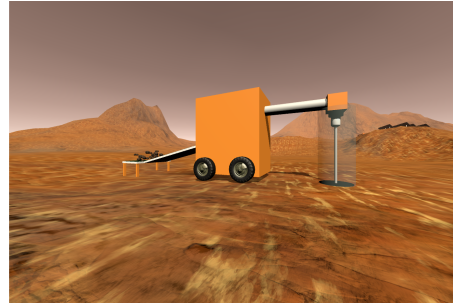


Figure 2. The Drilling Site

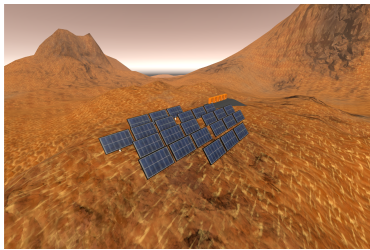


Figure 3. The Solar Panels

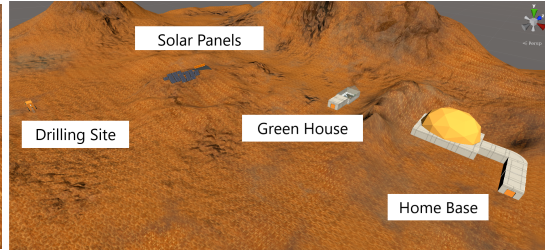


Figure 4. The map of the experience holds the Home Base, the Green House, the Drilling Site and the Solar Panels

4.3 Gameplay and Mechanics

To show the player all the information he needs to finish his tasks and also to add game mechanics, it was necessary to create a Head-Up-Display (HUD) system, in this case displayed at the player's left or right wrist. To display the current oxygen and radiation level (see below) the left wrist is equipped with two sliders, one for the radiation. To show the user what he is supposed to do the right wrist also got a HUD which always shows the current mission/goal. (cf. Figure 5)

To make it easier for the player to fulfill the tasks and find their way, there are several highlighters set on the map which are switched on if the mission requires the user to do so, and switched back off when the player has arrived at the corresponding location.

One of the main interaction methods used in the experience are buttons (cf. Figure 6). To activate A button, the player does not have to press a button on the controller, but simply extend his index finger and move it towards the button until he pushes it.

Many objects in the experience can get grabbed by the player. For that, the user has to press the "grab button" or simply make a fist. By that, the grabbable object sticks to the hand and it can get moved/rotated in any direction. The

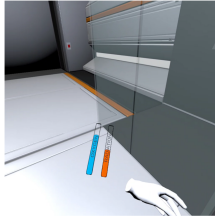


Figure 5. The left and the right HUD

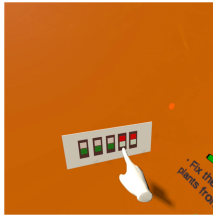
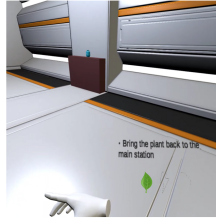


Figure 6. Some buttons.



feature of picking up objects is for example used when analyzing plants in the green house.

As a gameplay element, the player has to always keep an eye on his oxygen and radiation level. If the oxygen runs out, or the radiation level hits the maximum, the game is over.

4.4 Missions and Challenges

The player basically has to fulfill three missions:

1. **Analyzing the plants in the green house.** The player has to get to the green house. Inside there is the “Plant Analyzer”, a fictional machine which can specify if a plant is toxic or not. The user has to grab one of the plants and put it on the analyzer. If the display shows that the plant is edible, he has to take it with him and bring it back to the main base.
2. **Collecting stone probes from the drilling site.** Here the player has to collect at least 3 stone probes and bring them back to the main base.
3. **Repairing the power generator at the solar panels.** Since the plants located in the green house need a decent warm temperature, they are relying on the power supply from the solar panels. The player gets prompted that he must reactivate the power supply to save the plants. There is also a slider which indicates how much time the player has left.

Besides these 3 missions, the player always has to check his oxygen resources and radiation level. If the player is inside and the doors are closed, he does not lose oxygen and does not gain radiation. To defuse the radiation he can use the “Radiation Defuser” in the main base, but he can only use it once in the whole experience.

In a very early stage of the project, the only possible way for the player to switch his location was by “teleporting” to fixed positions. Later on, we decided that it would be better if the player can move around freely, since that provides more freedom. Unfortunately, this has the side effect of increasing the occurrence of motion sickness for some people.

5 Evaluation and Discussion

To see if the experience would have an effect on peoples perception of Mars, a couple of persons were asked to do a full play through of the game. Overall, 7 people participated: 4 men and 3 women. Their age ranged from 26 to 64. None of the participants had a scientific background, or special previous knowledge about the subject. In advance, the people were asked to answer a questionnaire. It consisted of basic statements about conditions on Mars, general perception of the red planet, as well as if they had ever experienced virtual reality before. The people had to say 'yes' or 'no', to state if their opinion matches with the statement or not:

1. "I support attempts to land astronauts on Mars."
2. "Mars is a suitable alternative to Earth for humankind."
3. "It is possible to survive on Mars without a space suit."
4. "There are water resources on Mars."
5. "Temperatures on Mars' surface are similar to Earths' surface."
6. "Just like Earth, Mars has a thick atmosphere."
7. "I have tried virtual reality before."

During the actual experience, they were introduced to the controls and got a pair of headphones to achieve a higher immersion. If the participants had problems to finish the tasks, they received a hint.

After they had finished the experience - either by loosing or by completing the game - they got a second questionnaire with the same questions, but without question nr. 7. It turned out, that everyone who was supporting Mars expeditions in the first place, did not change their opinion after the experience. Everyone who thought that Mars was a suitable alternative to Mars changed their opinion, although some mentioned that Mars was not the best, but "the only alternative" to earth. Every participant knew that it is impossible to survive without a space suit on the red planet, and also everyone knew that there is water on Mars.

However, none of the participants knew, that Mars has in fact a very thin atmosphere instead of a thick, and also did not know it after the experience. Only a few were correct about the drastic temperature differences on Mars, everyone knew it after the experience. Every participant learned about the toxic soil and the radiation in the experience.

Overall the participants did well in fulfilling the prompted tasks. Unfortunately, some of the players suffered from motion sickness during the experience, and one of them even had to stop because of this. Another point of criticism was the lack of action or music.

6 Conclusions and Future Work

The results clearly show that "Survival On Mars" has an effect on peoples perception on Mars. For future work, a revision of the existing game with a more

focused approach on entertainment would probably be beneficial of the overall experience and could also lead to a much greater impact on peoples opinions.

Even though the experience raised awareness about how hostile Mars is, the desire to settle Mars, still is - such as the general wish to explore the universe - deep embedded in our society and will probably remain there.

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