

Virtual Reality Roller Coaster: From Fear to Thrill – Without Leaving the Room

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Figure 1: Main scene of our brand-new VR roller coaster experience.

ABSTRACT

This report contains a detailed description of our brand-new interactive virtual reality roller coaster application deployed for HTC Vive. Application includes an immersive roller coaster experience and functionalities of dynamical choice of tracks, change of play modes, object interaction. Additionally, user discomfort recorder is included, logging real-time user feedback during the game. The latest Tobii eye tracking is used for object interaction and feedback recording.

Index Terms: VR, roller coaster, virtual ride.

1 INTRODUCTION

With numerous types of VR headsets readily available directly to the public, Virtual Reality is already becoming a tangible reality for many – all in the comfort of their own home, by making use of their own smartphone. Google Trends indicates a steady increase for the search term “Virtual Reality” over the past five years, with a notable spike occurring during 2016 (Google Trends, n.d.) [1], which can be connected to the release of Oculus Rift (CV1).

As virtual reality allows for several modifications and extensions of the actual track layout, the size of the virtual reality track can be much larger than the real one.[2] This of course means that speeds can be much faster and heights much taller, as these aspects also grow with the increased dimensions. Most of all, there is no need to show an actual track or rails (which would give away what element comes next), other than for dramaturgical reasons. As the rider is totally immersed in the virtual reality world, one can even be tricked by giving hints on a wrong track direction and then e.g. have a giant creature grabbing the virtual cockpit and carrying it

into a different direction (which turns out to be the actual direction of the rails). Also, the effect of physical track elements like block brakes can be utilized in the virtual reality experience for dramatic elements like crashing through a virtual barrier or building.[3] Riders report after their first virtual reality roller coaster ride that it is unlike anything they have ever experienced before.[4]

While virtual reality roller coaster simulations quickly became quite popular after the appearance of the Oculus Rift, it showed that dizziness and motion sickness, known as virtual reality sickness, would be a major problem.[5] This was caused by the offset between the simulated motion in virtual reality and the lack of real motion, as the inner sense of balance wouldn't feel the appropriate forces and turns.[6]

2 RELATED WORKS

The first VR roller coaster experience that became publicly available was Alpenexpress Coastality created by MackMedia and VR Coaster and deployed in Europe-Park in Germany on September 17, 2015. Although that was a combination of a ride on a steel roller coaster and a virtual visual stream to users through head-mounted displays.

As for fully virtual experience, these started emerging later than the mixed ones. One of the reasons for that could be high dizziness and motion sickness during virtual roller coaster experiences where users are stationary. Another plausible reason is that head-mounted displays became more affordable, smartphones got more computational power and, along with Google Cardboard, allowed a much more accessible VR experience.

One of the first fully virtual VR roller coasters was published in August 2014 by Mad Data GmbH & Co. KG. After nearly two years of silence on the market of VR roller coasters, 2016 gave birth

to dozens of applications. Some of the most influential companies that are making a mark in the virtual reality gaming space are Owlchemy Labs, Improbable, SVRVIVE Studios AB, Unity Technologies and Ubisoft.

3 METHOD

Our application is a user interaction-based roller coaster. A user can collect or dodge objects along the track of the roller coaster, and enjoy the ride simultaneously. There are two types of scenes the user can choose: Journey scene and Adventure. The Journey scene, located in the middle of a rainforest, is mainly focused on the interaction rather than the thrill. While the Adventure scene, which takes the user to the Christmas season, does include objects that a user can interact with, and is a much more thrilling track.

Two types of track scenes exist because our application is focused not only on immersive roller coaster, but also on interactive experience. A user can immerse into a scene better due to our tracks that mimic the basic principle of real world physics. Moreover, the tracks generate sound effects that can make the user feel the speed of the roller coaster. This is done by varying the pitch and the intensity of the sound effect. The faster the cart is travelling, the higher the pitch goes up and the louder the volume becomes.

In addition, the intensity of the sound effect varies by distance like in the real world. For instance, if you are in the proximity to a monkey screaming, the noise becomes louder and, otherwise, it becomes smaller. Another crucial element in immersive roller coaster is the position of the user's viewpoint. It should align with a real roller coaster ride's viewpoint. The gap between the reality and the virtual environment must be as small as possible for the user to immerse in the scene. Thus, similar to the real world conditions, where people must be seated on a roller coaster ride, we have fixed the positional change when the user is on the ride, and only allowed the rotational change.

4 IMPLEMENTATION DETAILS

In this section, we will discuss about the functionalities of the application, and explain how they were implemented.

4.1 Roller Coaster Tracks

The roller coaster tracks used in the application were developed using two plug-ins: Tracks and Rails, and Animated Steel Coaster Plus [7,8]. Tracks and Rails is a plug-in application that helps user build a roller coaster track in the Unity editor, as well as providing the built-in configuration that imitates the physics of the real world: an object decelerates in an uphill, and accelerates in a downhill.



Figure 2: Roller coaster track consists of smaller parts manually put together.

The latter, Animated Steel Coaster, gives the user more immersive experience with its realistic tracks and rails. Thus, we decided to use these two plug-ins to develop our application, but configuring the tracks by ourselves so that it can suit our purpose, interactive immersive roller coaster track, of the application. However, we had to modify some properties of the tracks because of our real-time velocity change function. We have set the cart track speed to a constant value in order for the cart to travel at the equivalent velocity all time. Anytime during the ride, when a user adjusts the travel speed of the cart, the cart stops making the cart's speed to zero. Thus, to reflect the modified speed instantly, it is necessary to set the acceleration value of the tracks with the constant positive value all times.

4.2 Object Interaction

In our application, user is encouraged to interact with objects present in the scene – primarily through a hand-held controller and gaze.

In the main scene, eye tracker Tobii is used for selecting the roller coaster track, i.e. gaze-based selection is implemented. In the "Journey" scene, the experience is made even more immersive by our placing of statues shooting arrows at the moving cart. Statues are activated when the cart is closer than a threshold distance, which triggers automatic shooting of arrows every 3-4 seconds. As the arrows collides with specified user's collider, it produces a sound and disappears from the scene. Additionally, monkey statues get activated as the cart moves along the track, producing a sound with the purpose of slightly disorienting a user.

In the "Adventure" scene, a number of Olaf statues are not stationary: one of them greets the user at the beginning of the track, some other ones throw snowballs at one another and at the user. Once the snowball hits the user, it splashes on the screen, obstructing the view. Another interactive part of the track is little Santas popping up along the way.



Figure 3: Interactive Santa holding a gift that is inactive (left) / active (right).

These are holding a present, which can be grabbed by the user using trigger button on the controller. Specific present is selected by gaze, namely looking at the present changes its color and size to better represent selection.

4.3 Play modes

Three different speed levels are implemented: the standard, 1.5 times faster and 2 times faster. Speed menu opens by pressing “Menu” button and swiping left/right on the touchpad to change the value. While the menu is up, the movement of the cart stops, although that does not stop the scene: user can still rotate the camera, statues can shoot arrows, and Olaf’s can throw snowballs.

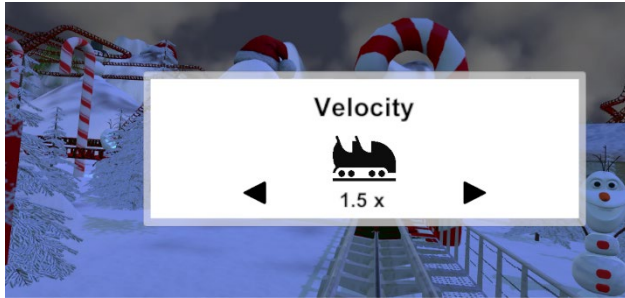


Figure 4: Speed change menu.

Another feature is day and night modes: user can switch between the two by gently swiping down on the upper part of the touchpad. During day mode, direction light located at infinity illuminates the scene, while during the night the sky is much darker, with stars and/or the moon, and lights are on all around the scene.



Figure 5: Night mode on Adventure scene.

4.4 User feedback

For a user discomfort recorder, we implemented automatic logging of the user’s position and rotation at each frame. This information is stored locally on the machine, in the format as follows.

```
...
2019/04/27_09:38:58|(158.8, 1.7, 116.5)|(0.0, 0.9, 0.0, -0.4)|(-0.1, -0.4, 0.0, -0.9)
2019/04/27_09:38:58|(159.4, 1.7, 117.0)|(0.0, 0.9, 0.0, -0.4)|(-0.1, -0.4, 0.0, -0.9)
2019/04/27_09:38:59|(159.9, 1.7, 117.4)|(0.0, 0.9, 0.0, -0.4)|(-0.1, -0.4, 0.0, -0.9)
2019/04/27_09:38:59|(160.4, 1.7, 117.9)|(0.0, 0.9, 0.0, -0.4)|(-0.1, -0.4, 0.0, -0.9)
...
```

Figure 4: Example excerpt of logged position and rotation information stored locally.

This data is stored with the purpose of analyzing user behavior on different parts of a roller coaster track, evaluating their activity, level of engagement, as well as motion sickness.

Apart from that, we implemented a manual user discomfort recorder, are few parts where improvements can be made. First, we can which user operates by pressing the touchpad during the ride. Every time optimize the meshes that are used in the scenes. Depending on the

the button is pressed, we record the position and rotation of the user and store that data to then visualize. In particular, after user finishes the ride, we place the cart into fixed positions when user manually recorded discomfort, so that the user can look around, see where this part of the track is, and reflect on why discomfort was present at that particular point.

Moreover, we have an extra feature called “Happy Place”. This is a safe space, which user can evacuate to at any point of their ride, e.g. in case they are not feeling well and would like to end the ride. Happy Place is designed to be as pleasing to the eye as possible, built as a home cinema with sky wallpapers, white pillows around, and cute videos of animals to choose from. This cinema is equipped with videos of puppies, kittens, bunnies and little pandas, which user can pick from by swiping left/right on a touchpad and play/stop by pressing on the touchpad. Happy Place is our novelty feature which, in its simplicity, offers a user a comforting place to take a break, relax for a minute or two, to get the best possible overall experience.



Figure 6: Interactive Santa holding a gift that is inactive (left) / active (right).

5 RESULTS

We have successfully implemented a VR rollercoaster system that includes the following features:

- At least two shapes of tracks, including rotations in three degrees of freedom (roll, yaw, and pitch)
- A user interface to choose different tracks immersively, play modes
- User discomfort recorder, logging real-time user feedback during the game

It provides a high-quality immersive VR experience, takes care of user’s well-being and incorporates interactive gameplay.

6 DISCUSSION

Our application is able to provide a user a unique experience of interacting with the user’s surroundings and riding on a thrilling roller coaster at the same time. Also, in virtual reality environment, it is important that a user can immerse in the environment. Since our application utilizes a user’s gaze to select a menu, we were able to minimize the number of buttons that the user needs to memorize in the game. We believe that this may help a user to be more immersed in the environment. However, as our future work, there are few parts where improvements can be made. First, we can optimize the meshes that are used in the scenes. Depending on the

machine the application is executed on, a user has experienced intermittent slowdown of the application. Thus, we may need to decimate and merge the meshes that has similar materials, and this may lead to better user experience with improved render performance. Moreover, we are planning to add more objects that are able to interact with a user.

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