VISUALISATION OF AUTONOMOUOS VEHICLE INTERIOR IN VIRTUAL REALITY

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Abstract

In this paper we present the visualisation process of autonomous vehicle interior using virtual reality (VR). Autonomous vehicles are providing designers with more freedom in the design, since some traditional elements like driver position and controls are not needed. In addition, the autonomous vehicles are usually envisioned as a form of urban public transport in the future, meaning their interior should be designed to accommodate several passengers. The use of 3D models and renders is suitable for presenting the design of the interior of these vehicles, but the sense of space volume and ergonomics are not well presented. Using VR, we can provide full immersion of the user, providing the ability to completely visualize the interior of the vehicle. In addition, using game engines we are able to provide a complete virtual experience of the autonomous ride in an urban environment. In that way, visualisation in VR could be used to verify the design methodology utilized in the design process and verify the utilized interior design ergonomic standards.

Keywords: visualisation, virtual reality, interior design, autonomous vehicles.

1 INTRODUCTION

1.1 Autonomous Vehicles

Autonomous vehicles (AV) are the next step in the automotive technological development. In general, this type of vehicles are usually envisioned as a form of urban public transport in the future, meaning their interior should be designed to accommodate several passengers. With this, AVs also provide a better efficiency since they are operated by an software algorithm that selects best routes and speeds rather than when vehicles are operated by a driver. In AVs the user is a service receiver.

Autonomous vehicles have to provide a level of functionality and efficiency while driving that are greater compared to conventional vehicles. In addition, AVs have to provide level of comfort that will make the user to utilize that service continuously. When we say comfort, we mean ergonomics of the interior for a passenger in a seated position along with free space to move, pockets and compartments position and capacity, holders and displays for interaction.

Since there is a large number of components that comprise the entire ergonomics of the interior in an autonomous vehicle, they have to be designed/adapted for a range of users with anthropometric characteristics of standard percentiles. The focus here must be on the opportunity to widen the range of users and that includes people with disabilities as potential passengers. Having all this in mind, the approach towards interior design of AVs has to redefined as inclusive in order to achieve high standard of comfort and efficiency for the widen target group.

Autonomous vehicles, or self-driving vehicles have reached a high level of relevance in last few years. This is in line with the fast pace of technology development. Most of the companies are focused on transport of goods rather than passengers due to strict level of regulation and technical challenges connected to AVs for passengers. Until now, there has not been a company that has achieved commercial scale of bigger proportion when it comes to AVs for passengers or personal transport [1].

The leaders in this field are still in a phase of development of concepts, while smaller companies have been focused on services for public transport with AVs using existing platforms [1].

1.2 Virtual Reality

The Virtual Reality (VR) systems provide users with ability to visualize in 3D the objects of interest. Compared to regular computer screens, VR enables the user to be immersed into the environment where the object of interest is going to be used [2]. In that way, the user can visualize but also put into scale the design. In addition, in VR the user is able to interact with the model and the environment. Interaction options range from passively observing the model, to move around in the environment, to being able to actively measure and manipulate parts of the model [2].

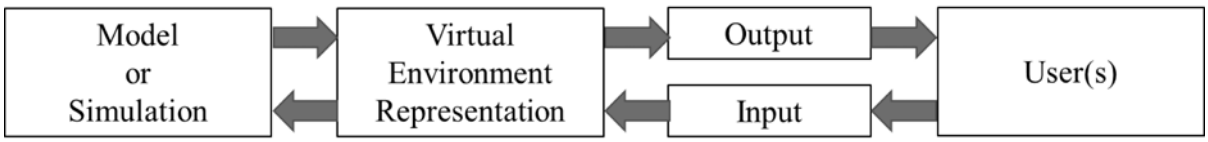

Fig. 1. VR System Architecture.

The general workflow of building a VR scene is divided in three major stages: input data acquisition, 3D modelling and rendering, and visualization to target device or service. Using 3D modelling tools, 3D models are created manually or using automatic computational methods, or a combination of both. The created models can then either be used as input for some spatial analysis tools, directly used with some presentational tools, for example, to embed an animated version of the model on a web page, or the models are exported/imported into a 3D application building software, which typically are game engines such as Unity3D or the Unreal engine, and build an application around the 3D models [3].

2 METHODOLOGY

The design process of an ergonomic interior of AV the following a three-phase methodology was utilized [4]:

Concept and sketch creation

Creation of 3D models

3D model presentation in VR

The first step of the first phase is creating concepts. In this step the goal is to define the general shape and dimensions of the interior. According to the purpose of the AV (public transport in urban areas) and the defined standards and requirements of the target group, it is clear that the most suitable vehicle category is M2, that is vehicles used for the carriage of passengers, comprising more than eight seats in addition to the driver's seat, and having a maximum mass not exceeding 5 tonnes. An existing platform that fulfils all of the requirements is the vehicle model Sprinter by Mercedes-Benz. In this way, we will have defined dimensions fulfilling all standards for vehicle approval so we can focus on the design of the interior [4].

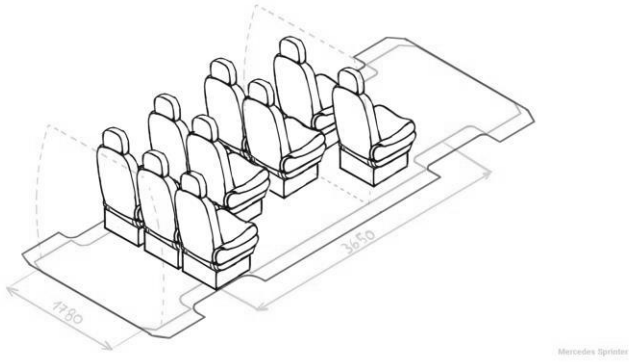

Fig. 2. Platform of Mercedes Sprinter.

The second step is to define the layout of the seats according to the number of passengers, the required free space for movement and space between the seats, leg room, distance between the passengers, reach of hands etc [5]. The design of the seats is based on previously defined ergonomic measures, while their position in the interior is adaptable dependent on the predefined criteria.

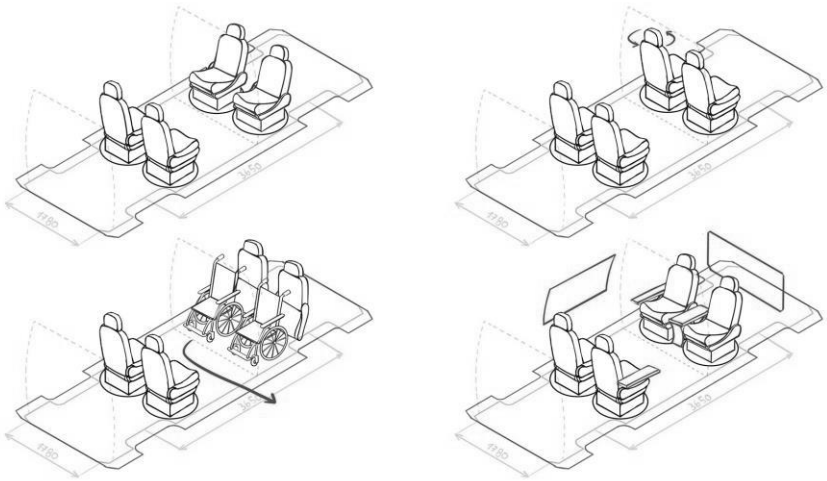

Fig. 3. Sketch of the seats' configuration.

In Fig. 3 basic sketches are shown with possible configuration of the seats in the interior. The possibility for folding of the seats is also analysed in other to create space for wheel chairs. The sketches present the position of different additional elements in the interior like displays, armrests etc [6].

In the next step, various concepts have been developed as 2D graphics. They are all based on the previously conducted research about the interior of AVs, aesthetic and design trends and user requirements. The various concepts show the position of seats in the interior along with additional elements like displays for interaction and information. The concepts also present various modes of folding and unfolding of these elements in order to fulfil the desired functions of the AV.

Each concept has some specific characteristics like following the principles of modern, simple and clean design using whites, greys and dark blues to achieve a formal and high-tech atmosphere. Other concepts try to associate to sport vehicles using high contrast primary colours and dark grey, with sidewalls that contribute to an energetic and focused feeling.

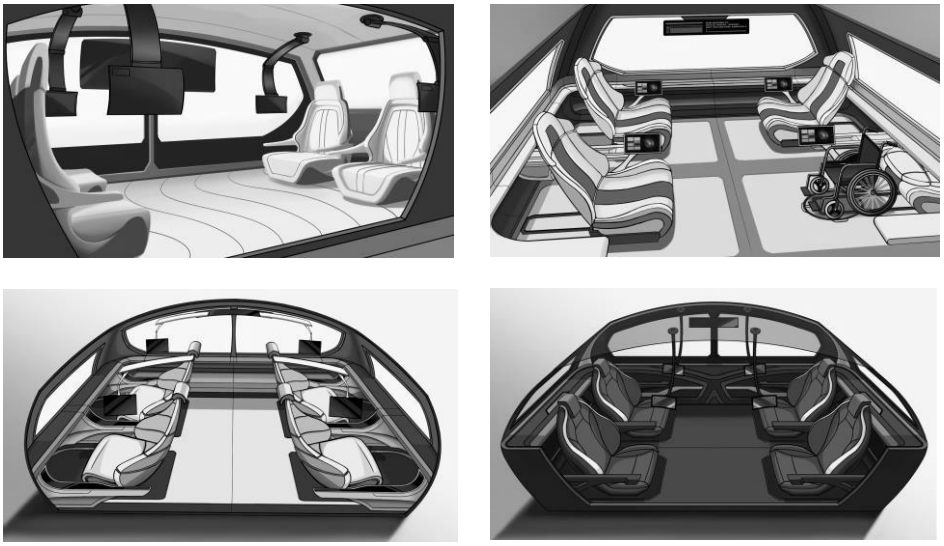

Fig. 4. Concepts of interior design of AV.

The second phase of the utilized methodology is to create the 3D model. For this project the software package Autodesk Maya was used. While creating the model of the interior, a model of a human in general position was introduced to the scene in order to create general feeling and scale of the objects in the interior. The base of the model is created using the dimensions of the selected vehicle platform. A rough design of the interior is created using the models of seat and placing them in the desired configuration. In the next step, a 3D model of one fourth of the interior is created with details. For this step a reference model of a human in a neutral seated position is used. The floor, walls and seat are key elements that define the space around the passenger. All of them are modelled according to the predefined standards, functionalities and ergonomic measurements.

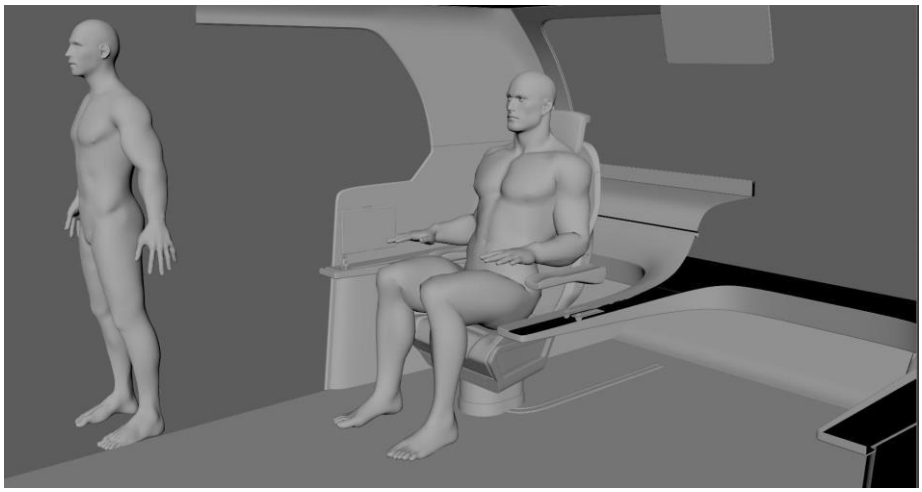

Fig. 5. Creating the 3D model of the interior.

In the next step the models are detailed and basic materials are applied to all elements. When this process is completed, a symmetrical mirroring of the model is created along x and y axis in the scene. Larger elements like the floor, walls and roof are joined with the original model through the border polygons. The last step is focusing on the final design of the scene through grouping the objects in UV sets and using generic materials. In this way, objects with similar material are better organized for texturing. The texturing is done using the software package Substance Painter. Each model is unwrapped as a 2D surface and appropriate textures and materials are created. The necessary maps for material colour, reflection, material roughness, unevenness, and gloss are generated. These are diffuse, specular, normal, bump, roughness, and displacement maps.

The third phase of the methodology is the visualisation in virtual reality. In order to do this, the software package Unreal Engine 5 was used. After setting up the scene with HDRI environment map, sky atmosphere and sky light, post process volume, cine camera actor and sphere reflection capture the interior model is introduced as .fbx dataset. In the next step virtual passengers are added using Quixel Bridge and the Megascans library. Metahuman is a digital tool for creating high quality fully functional human models. For this project, four different metahuman models have been used in order to present the interaction between the passengers and the interior of the vehicle.

Fig. 6. Render of the interior in Unreal Engine 5 using Metahuman models.

In the next step the vehicle is positioned in a virtual city created in Unreal Engine 5 available for download through the Epic Store. The city sample is used as demo to show the capabilities of the Unreal Engine 5 and it contains objects in detail, parks, streets, and fully automated traffic. The interior model created for this project is static, so it is necessary to introduce it to the traffic system using the list of objects that consist the traffic system (Blueprint). The Unreal Engine 5 software package has a built-in module for Virtual Reality. By simple adding the module to the scene and setting up the parameters of the virtual camera the complete project can be visualised in VR.

Fig. 7. Visualisation of the AV interior in VR using HTC Vive headset.

For this project a headset from HTC Vive series 1 was utilized. In this way a complete immersive visualisation in VR was created where the user of the headset can visualize the ride in an AV, see the complete interior of the vehicle, interact with the UI system and the other passengers and get a better feeling about the ride.

Fig.8. Experiencing ride in AV using VR.

3 CONCLUSION

This paper presents the ability to visualize an interior of an autonomous vehicle in Virtual Reality. This ability has shown that it results in a much better visualization where the user is fully immersed in the scene. In that way, the user has a better understanding of the interior with ability to visualize and feel the space around, the size of elements, the interaction of various elements, moving of passengers in and out and numerous other parameters that are not available to comprehend using render or 3D model presented on a screen. The paper presents a straightforward methodology for creating VR experiences and key elements in the process.

By including VR in the early design stage, engineers and designers can benefit from the features of VR by being able to visualize the interior in real scale and intervene in the design to improve the functionality. Being able to observe the entire working environment is important, especially for the development process of a complicated product like the autonomous vehicle interior.

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