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Construction of Virtual Reality Rail Transit Simulation System

Abstract: - In order to enhance the quality of professional technology research and development and personnel training in rail transit, this study constructed a virtual reality rail transit simulation system, including the data input and processing of vehicle driving environment, vehicle structure and station scene data, as well as three-dimensional modeling and data storage. The data is stored in the Internet cloud server, which increases the accessibility and sharing of the data, and the rail transit simulation can be realized by calling the three-dimensional model in the cloud server. This efficient and convenient virtual reality content development tool helps to improve the level of scientific research and development and the quality of talent training in rail transit, it will also be the inevitable trend of the development of rail transit industry in the new era.

Keywords: Data Set, 3D Model, Virtual Reality, Cloud Server.

I. INTRODUCTION

By 2022, China's railway operation mileage had reached 155,000 kilometers and the number of employees will reach nearly 4 million [1]. According to the statistics of the China Rail Transit Association, the skilled personnel in the industry accounted for 84% [2], showing that the industry has a large technical content and a high proportion of professional technical personnel. With the rapid development of the rail transit industry, Rail transit simulation software has been widely used in railway line planning, simulation operation, vehicle structure design and traffic management the application of new technologies and training tasks for professional technical personnel are increasing day by day. However, its technical training means are relatively backward, and the training mode and quality cannot keep up with the needs of personnel training, which has become a technical bottleneck restricting the sustainable development of rail transit. The high-efficiency, high-quality and low-cost personnel training mode has become an urgent problem for the development of the industry [3,4,5,6,7,8,9,10,11,12,13,14]. In this case, it is very necessary to use virtual reality rail transit simulation system to train new employees and on-the-job employees on new technologies and job rotation.

A. Greatly Reduce the Cost of Training

First of all, in the process of technical training, the need for prototype and training sites, and prototype production and training needs to spend a lot of time, virtual simulation system construction, cost savings can also be achieved by reconfiguring training sites and acquiring equipment to avoid differential training requirements, as well as by the wear and tear caused by the reuse of machines [15]. In addition, in the technical learning and training of employees in the entire industry, the existing rail transit simulation technology and the construction model are constructed manually, which leads to high simulation cost and long production time of the entire animation. Therefore, it is urgent for the industry to establish a rail transit simulation system based on virtual reality [16].

B. Effectively Improve the Practicability and Effectiveness of the Training Results

The ability of virtual reality technology to provide technical training for the rail transit industry is becoming increasingly prominent, and it is becoming the preferred path for upgrading the technical training of rail transit employees. In the training of talents with the upgrading of professional and technical level of the industry, it is an inevitable trend of the development of the rail transit industry in the new era to use virtual reality technology to accelerate the application of the rail transit industry scene, deepen the organic integration of virtual reality and the industry, and create a B-terminal universe model [17].

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C. *Not Affected by External Conditions*

The virtual reality rail transit simulation system only completes the operation and movement of vehicles in the virtual environment, and is not affected by the natural factors such as temperature, climate, day and night, flexible data acquisition and processing.

II. RESEARCH BASIS

Rail transit system is very complex, so in order to get a most practical simulation results, need to master a variety of professional technical capabilities. The research basis of this project includes the following technical expertise that we possess. The main ones are:

A. *Virtual Reality Software and Hardware Technology and User Experience Design*

This system is based on the Unity3D platform, mainly using JavaScript language development, WebGL rendering, and then through the Unity3D platform by Web compilation and use. Need to be able to cross-platform use, support Windows, Unix, support a variety of RDBMS, at least Oracle, SQL Server, MySql, support JDK1.5 running target software environment; A development environment that supports running tools like Unity3D, JavaScript, Tomcat, JDK, iBatis, webwork, SQL Server, or Oracle or MySql, Dreamweaver MX, Eclipse, ANT, JUnit, and more[18,19,20,21,21,23]

To master the creation of virtual environment, interactive and three-dimensional modeling. Firstly, I am familiar with Adams Software [24,25] , which is used to analyze the whole performance of mechanical system, secondly, I have to master virtual reality modeling software such as 3Dmax, C4D, Unity, Unreal Engine, etc. Also need to understand the vehicle structure, vibration dynamic characteristics of the analysis and evaluation of the software Ansys [26]. There are relations and data interaction between the software of each system, and the software should be integrated into an integrated system.

Master the creation, interactivity and three-dimensional modeling of virtual environments. Be familiar with virtual reality devices such as head-mounted displays, joystick controllers and motion sensors to provide user interaction with the virtual environment. Understand user experience design principles to ensure the ease of use and attractiveness of virtual reality rail transit simulation systems.

B. *Knowledge of Rail Transit*

Professional knowledge of rail transit system, train operation, station management, etc., to ensure the accuracy and authenticity of the virtual simulation system [27].

C. *Make Full Use of Computer Technology*

We master computer programming skills, especially programming languages related to virtual reality technology, to create interactive simulation environments. We have a good knowleage of how to process and manage data about the vehicle driving environment, vehicle structure, and station scenarios in order to effectively input it into a computer model [4]. We Master cloud computing and data storage technologies to ensure accessibility and sharing of virtual reality models [28].

D. *Education and Training Knowledge*

Understanding of best practices of education and training in the field of rail transit to ensure the effective use of virtual reality simulation systems in this professional technical training.

III. RESEARCH METHODS

First, we choose a real rail transit scene as the simulation object, which simultaneously consists of the advantages of related scenes to build a new system, as shown in Figure 1:

54x54 image data block or a 36x36 image data block is used over the network and contains 5 convolution layers, 2 maximum pool layers and 3 full connection layers. The network uses a graphical model for the pose detection of the original object, which can detect the pose and shape connections contained in the image. This method combines the flexibility of graph representation and the precision of statistics. It can not only detect the pose and shape of image accurately, but also solve the problem of fuzzy model. Then, using the reconstruction process of PCA algorithm, the 3D model sequence with the same topology structure is processed to extract the data that can be edited. Edit the model by modifying the data. Thus, the vehicle driving environment data, the vehicle structure data and the station scene data of rail transit are obtained, which correspond to the vehicle driving environment data set, the vehicle structure data set and the station scene data set, before obtaining the data set, the

parameters of the relationship between parallax and scene depth, virtual stereo camera parameters, and viewing comfort zone model are analyzed in-line. Based on the off-axis shooting model of virtual stereo camera, the mapping relationship between Parallax and depth is established, and the parallax gradient of stereo image is generated, accurate Parallax calculation, visual display, equipment adaptation and accurate control, including the following steps:
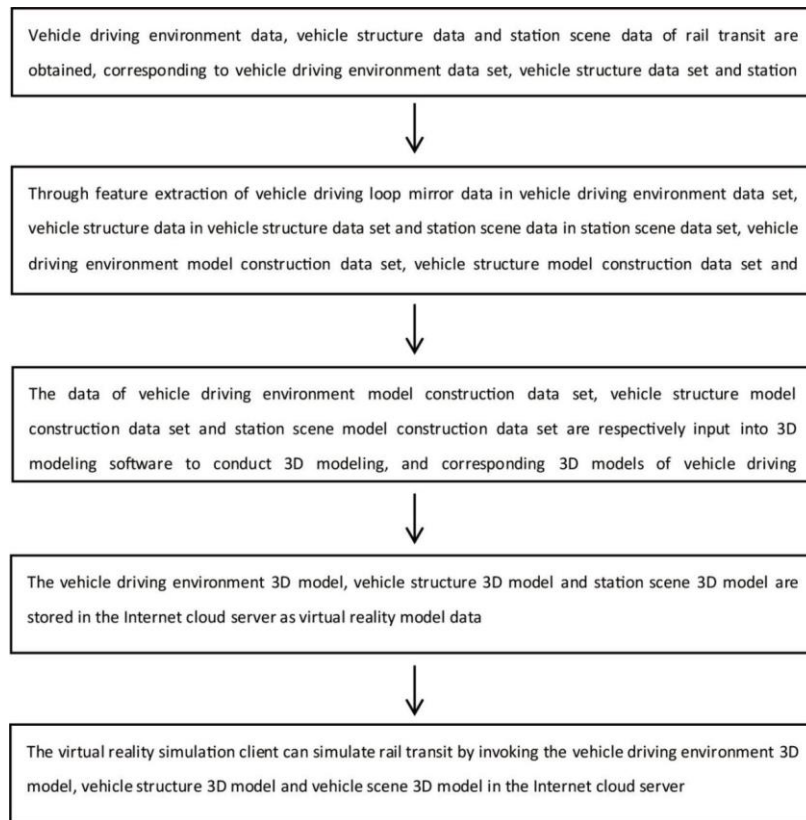
```
┌─────────────────────────────────────────────────────────────────┐
│ Vehicle driving environment data, vehicle structure data and      │
│ station scene data of rail transit are obtained, corresponding    │
│ to vehicle driving environment data set, vehicle structure data   │
│ set and station                                                    │
└─────────────────────────────────────────────────────────────────┘
                                │
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┌─────────────────────────────────────────────────────────────────┐
│ Through feature extraction of vehicle driving loop mirror data in │
│ vehicle driving environment data set, vehicle structure data in   │
│ vehicle structure data set and station scene data in station      │
│ scene data set, vehicle driving environment model construction    │
│ data set, vehicle structure model construction data set and       │
└─────────────────────────────────────────────────────────────────┘
                                │
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┌─────────────────────────────────────────────────────────────────┐
│ The data of vehicle driving environment model construction data   │
│ set, vehicle structure model construction data set and station    │
│ scene model construction data set are respectively input into 3D  │
│ modeling software to conduct 3D modeling, and corresponding 3D     │
│ models of vehicle driving                                          │
└─────────────────────────────────────────────────────────────────┘
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┌─────────────────────────────────────────────────────────────────┐
│ The vehicle driving environment 3D model, vehicle structure 3D    │
│ model and station scene 3D model are stored in the Internet cloud │
│ server as virtual reality model data                               │
└─────────────────────────────────────────────────────────────────┘
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┌─────────────────────────────────────────────────────────────────┐
│ The virtual reality simulation client can simulate rail transit   │
│ by invoking the vehicle driving environment 3D model, vehicle     │
│ structure 3D model and vehicle scene 3D model in the Internet      │
│ cloud server                                                       │
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Figure 1: Flow Diagram of Virtual Reality Rail Transit Simulation

A.   Create a Rail Transit System Image Data Sett

Obtain vehicle driving environment data, vehicle structure data and station scene data of rail transit, corresponding to vehicle driving environment data set, vehicle structure data set and station scene data set,

1)   Collecting the image information of the running environment of rail transit vehicles

Shoot images or videos of the driving environment of rail transit vehicles from multiple angles to obtain the vehicle driving environment data set

2)   Collecting the image information of external structure of rail transit vehicles

Shoot images or videos of the external structure of rail transit vehicles from multiple angles to obtain the external structure data set of vehicles;

3)   Collecting the image information of the inner structure of the rail transit vehicle

Shoot images or videos of the internal structure of rail transit vehicles to obtain the data set of the internal structure of vehicles;

4)   The vehicle structure data set is obtained by data integration

Integrate the vehicle external structure data set and the vehicle internal structure data set to obtain the vehicle structure data set;

5)   Collecting the image information of station external structure data sets

Take images or videos of the external structure of the station from multiple angles to obtain the data set of the external scene of the station;

6)   Collecting the image information of station inner structure data sets

Shooting images or videos of the internal structure of the station to obtain the data set of the internal scene of the station;

7)   The station scene data set is obtained by data integration

Integrate the station external scene data set and the station internal scene data set to obtain the station scene data set.

B. Create a 3D Model Dataset of the Rail Transit System

Vehicle driving environment data in vehicle driving environment data set, vehicle structure data in vehicle structure data set and station scene data in station scene data set are entered into the computer for feature extraction, and the corresponding vehicle driving environment model construction data set, vehicle structure model construction data set and station scene model construction data set are obtained. Specific steps are as follows:

1) Collect image data sets of rail transit system

Collecting vehicle driving environment historical data, vehicle structure historical data and station scene historical data of rail transit, corresponding to vehicle driving environment historical data set, vehicle structure historical data set and station scene historical data set; among them, vehicle driving environment historical data, vehicle structure historical data and station scene historical data are image data or video data.

2) Establishment of convolutional neural network.

Building convolutional neural networks usually requires the use of programming languages and deep learning frameworks. Take the following steps as an example:

import the required library:

```
import tensorflow as tf
from tensorflow.keras import layers, models
```

create a model:

```
model = models.Sequential()
```

add convolution layer:

```
model.add (layers.Conv2D(32, (3, 3), activation='relu', input_shape=(224, 224, 3)))
```

In this example, we add a convolutional layer of 32 filters, each with a size of 3x3, and use the ReLU activation function. The size of the input image is 224x224 pixels, and the specific parameters can be adjusted according to the requirements.

Add pooling layer:

```
model.add(layers.MaxPooling2D((2, 2)))
```

add more convolution and pooling layers and repeat steps 3 and 4 as needed.

Add a full connection layer:

```
model.add(layers.Flatten())
model.add(layers.Dense(64, activation='relu'))
model.add(layers.Dense(10, activation='softmax'))
```

Here we add two fully connected layers, the last one with 10 output units, suitable for classification problems.

Compilation model:

```
model.compile(optimizer='adam',
loss='sparse_categorical_crossentropy',
metrics=['accuracy'])
```

Training model:

```
model.fit(train_images, train_labels, epochs=10)
```

The model can be trained by providing training data (train_images and train_labels) as required.

3) Using the historical image data set, the features of the model were extracted

The convolutional neural network is built by using the vehicle driving environment historical data set, vehicle structure historical data set and station scene historical data set to train and obtain the computer feature extraction model

4) Complete the creation of the 3D model

Vehicle driving environment data in vehicle driving environment data set, vehicle structure data in vehicle structure data set and station scene data in station scene data set are respectively input into computer features for feature extraction, corresponding to vehicle driving environment model construction data set, vehicle structure model construction data set and station scene model construction data set.

Data from vehicle driving environment model construction dataset, vehicle structure model construction dataset and station scene model construction dataset are respectively input into 3D modeling software for 3D modeling, and corresponding 3D vehicle driving environment model, vehicle structure model and station scene model are obtained.

C. Store Virtual Reality Model Data

The 3D model of the vehicle driving environment, the 3D model of the vehicle structure and the 3D model of the station scene are stored in the Internet cloud server as virtual reality model data, as shown in Figure 2, including the following steps:
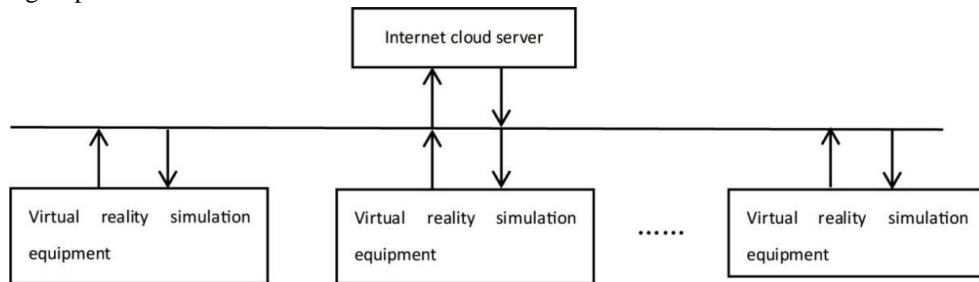

Figure 2: Structure Diagram of Virtual Reality Rail Transit Simulation System

1) Build the model database in the internet cloud server

Establish vehicle driving environment model database, vehicle structure model database and station scene model database in the Internet cloud server

2) Link to the 3D model in the cloud server

The vehicle driving environment 3D model, vehicle structure 3D model and station scene 3D model shall be stored in the vehicle driving environment model database, vehicle structure model database and station scene model database respectively.

D. Virtual Reality Simulation of Rail Transit

The virtual reality simulation device performs rail transit simulation by invoking the 3D model of the vehicle driving environment, the 3D model of the vehicle structure and the 3D model of the station scene in the Internet cloud server, including the following The virtual reality simulation device accesses the vehicle driving environment model database, vehicle structure model database and station scene model database in the Internet cloud server by obtaining access permissions;

- The virtual reality simulation equipment obtains the 3D model of vehicle driving environment, vehicle structure model and station scene model respectively from the vehicle driving environment model database, vehicle structure model database and station scene model database.
- Multiple model files are generated by 3D model of vehicle driving environment, 3D model of vehicle structure and 3D model of station scene in virtual reality simulation equipment.
- By using the JanVR engine editor to modify models in multiple model files and output their attributes to the
- JanVR engine, scene models are automatically constructed and rendered. In the process of modeling, AI technology can be used to think about reference objects from pictures or texts and then automatically model around the reference objects. This is a way of creating modern computer vision rendering models for 3D rendering tasks with deep learning.
- The simulation logic written by the script editor can realize the control of the changes of scene model and environment in the constructed scene, so as to achieve interactive and dynamic effects. Here is a sample script that illustrates how to achieve this effect:

```
# Import the required libraries and modules
import janvr_engine
import random
# Create scene objects
scene = janvr_engine.Scene()
# Create scene model objects
model = janvr_engine.Model("model.obj")
# Add the model to the scene
scene.add_model(model)
# Cyclic update scene
while True:
# Generate random model transformation parameters
translation = (random.uniform(-1, 1), random.uniform(-1, 1), random.uniform(-1, 1))
rotation = (random.uniform(-180, 180), random.uniform(-180, 180), random.uniform(-180, 180))
```

```
scale = random.uniform(0.5, 2)
# Set the transformation parameters of the model
model.set_translation(translation)
model.set_rotation(rotation)
model.set_scale(scale)
# Update scene
scene.update()
# Render scene
scene.render()
# Wait a while
janvr_engine.sleep(1)janvr_engine.sleep(1)
```

The above example code uses the relevant libraries and modules of the JanVR engine to create a scene object and a scene model object and add the model to the scene [9]. Then, by constantly updating the transformation parameters of the scene model and rendering the scene after each update, the interactive and dynamic effects of the model are realized.

Users can add more logic and functions to the script according to specific needs, such as model transformation according to user input, adjusting the ambient lighting according to time changes, and so on. By writing simulation logic through the script editor, the model and environment in the scene can be flexibly controlled to achieve rich interaction and dynamic effects.

IV. PROJECT APPLICATION

To use virtual reality rail transit simulation system to simulate general cargo train driving, the specific methods, as shown in Figure 3:
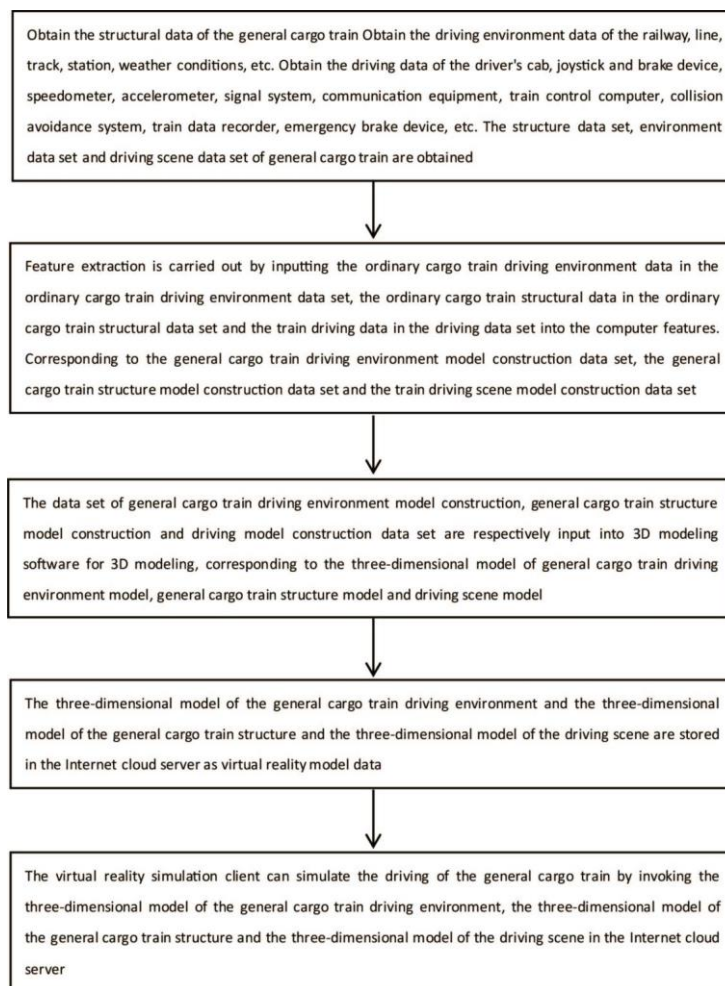

Figure 3: Flowchart of Virtual Driving Simulation

Through the above process verification, the virtual reality rail transit simulation system of this project to simulate train driving is a safe and effective training method, which is helpful to improve the driver's skills, safety

awareness and emergency response ability. It can be used to train new drivers, for emergency training, and for regular maintenance and upskilling.

V.   CONCLUSIONS

This project combines computer vision, 3D modeling and cloud computing technologies to provide an efficient and convenient tool for professional learning and training in the field of rail transit. The main significance of designing this approach is to improve the efficiency of model building in the field of rail transit, provide virtual training and professional learning opportunities, and realize the advantages of sharing and cloud computing. Here are the important implications of this approach:

A.   Improve Efficiency

Using computer feature extraction model technology, key features in vehicle driving environment, vehicle structure and station scene image or video data can be automatically extracted. This eliminates the tedious work of manual modeling and greatly improves the modeling efficiency.

B.   Virtual Training

The combination of 3D modeling and Internet cloud server can provide a virtual environment for professional learning and training in the field of rail transit. Engineers, technicians, students and teachers can use virtual models for rail transit simulation, virtual driving, simulation operations and virtual education.

C.   Multi-user Sharing:

Storing the 3D model in the Internet cloud server allows multiple user clients to access and use the model at the same time. This provides opportunities for collaboration and sharing between multiple users without the need to store large 3D data locally.

D.   Cost-effectiveness

Avoiding storing large 3D models on local computers can reduce hardware costs and storage costs. Cloud servers provide a highly scalable storage solution that can be used on demand.

E.   Experiment And Research

This method can be used to simulate different situations of the rail transit system, such as emergency situations, different design schemes, etc. This is of great significance for experiments and research, helping engineers and technical researchers to better design and study rail transit systems.

F.   Real-time Feedback

Virtual models can provide real-time feedback, allowing users to simulate various situations and see the results in real time. This is useful for real-time correction and improvement during training and learning.

Together, this approach combines virtual reality, computer feature extraction and cloud computing to provide an efficient, interactive and cost-effective learning and research tool for the field of rail transit. It helps to improve the efficiency and quality of rail transit system design, personnel training and research.

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