Factory Inspection Tour Support by Actively Using Virtual Reality (VR)

Makito Tominaga,
Nobuo Okazaki

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Abstract

Many products produced at our Computer System Factory are installed with very specific conditions. In many cases, they are used as module units and are combined with equipment to form a system. For a factory inspection tour, we inform visitors the purpose of this particular product. We need an innovative easy-to-understand explanation.

We developed a system to support a factory inspection tour by actively using Virtual Reality (VR) technology. This system is enabled to change the standard virtual viewing positions accordingly for a factory inspection tour or commercial negotiation. In a virtual space, product installations are reproduced realistically so that its functions can be effectively and visually explained. The first to be adopted was the Overhead Catenary System (OCS) inspection system "CATENARY EYE" VR system. With the development of this system, the challenges of routine conventional factory inspection tours were solved, and the system is helping visitors better understand and experience the product.

1 Preface

Our Computer System Factory is developing, producing, and maintaining the Supervisory Control and Data Acquisition (SCADA) system, remote supervisory control equipment (Tele-controller), Overhead Catenary System (OCS) inspection system "CATENARY EYE", computer-applied system products, and protection relay products. In a factory inspection, we often use real machines (our products) for the explanation of our product machines. If an actual machine cannot be used, panels are used for explanation. Due to the nature of the equipment, our products are used as modular units and are installed in special specific ways. A configuration is completed at the project site by combining it with system equipment. Consequently, it is difficult for visitors to fully comprehend the final vision of the system by simply looking at our individual module products. It is therefore necessary to devise a favorable method of providing clear explanations to interested visitors from other business arenas.

For an adequate solutions, we developed a factory inspection tour supporting system that fully utilizes Virtual Reality (VR). This paper introduces the outline of the VR factory inspection tour system and VR CATENARY EYE which is the first contents.

2 Outline of the VR Factory Inspection Tour System

2.1 VR Technology

VR technology is a general term for a computer-generated virtual environment simulating a reality in order for a human being to perceive it as a virtual reality. Currently, this technology is a Head Mounted Display (HMD) visual experience. Though this technology has been available in the last decade, it has recently received increased interest due to its enhanced "sense of immersion" from the improvement of computer graphic processing capability and device functions.

2.2 Challenges

Since the sense of immersion is intensified, some people experience "Virtual Reality sickness (VR sickness)". This type of discomfort stems from a sensory shift or gap between the sense of sight and information in the semicircular canals, much like motion sickness. There are differences among individuals in their adaptability to VR and a favorable device is necessary to meet the needs of as

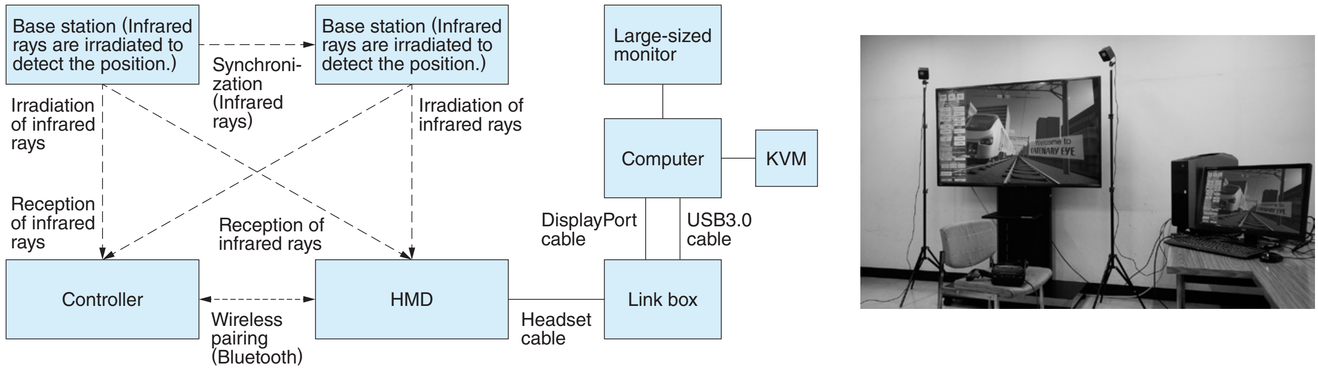


Fig. 1 **Overall Configuration of VR Factory Inspection Tour System**

Configuration and external appearance of the VR factory inspection tour system are shown. At the large sized monitor, an aspect of virtual space can be checked from the outside.

many people as possible. Another challenge is providing for a real space that is comparable to a virtual space for allowing people to walk around in the VR space. Because of specific restrictions where visitors are allowed to walk, a limit line to restrict access is needed. To conduct the tour with ease, it is essential to establish a realistic scenario.

2.3 System Configuration

In our system, we adopted a “seated experience” due to possible motion sickness and restricted areas so plant visitors can experience the VR tour sitting in chairs. Fig. 1 shows an overall configuration of the VR factory inspection tour system. The respective composing elements are as follows:

(1) Computer

In VR presentation, it is necessary to compute the space coordinates by continually tracing the movement of each visitor and maintain real-time drawing of a virtual space. This process requires a high-speed graphic processing capability. Our system employs the ALIENWARE computer produced by Dell Inc. with its computing ability to support VR game playing. For faster computation, we use the GeForce RTX 2080 by NVIDIA Inc. for the Graphics Processing Unit (GPU). Table 1 shows the computer specifications.

(2) HMD

This display device is worn on the head covering the eyes of the person experiencing the VR. For the HMD of this system and the base station and controller to be described later, we adopted the VIVE Pro by HTC Corporation. The provided display shows the projections of a VR space to both eyes respectively so that a stereoscopic VR view can present a 3D. The computer and HMD are connected through a headset cable.

Table 1 **Computer Specifications**

Computer specifications used for this plant touring system are shown.

Item	Specifications
Name	ALIENWARE AURORA R7
OS	Windows10
CPU	Core i7-8700
GPU	GeForce RTX 2080
Memory	16 GB
Storage	C Drive: 238 GB SSD D Drive: 1.81 TB HDD

(3) Controller

Using a hand-held chargeable device, “grip, pull trigger, and move/push the slide pad”, actions can be detected. These hand actions can be virtually linked with motions in the VR space, and a 3D object can be freely manipulated. The 3D object for the controller can be displayed in the VR space.

(4) Base station

The irradiation of infrared rays can be utilized to detect position and direction of the HMD and controller. One or two base stations are installed so that the moving space can fall within the scope of the infrared ray irradiation. Fig. 2 shows an image of the base station installation.

(5) Software

For our VR development, the Unity made by Unity Technologies, Inc. was adopted because this device is known for its versatility and easy handling. The Unity is a current product of the de facto standard in the field of xR※1 development including the VR. Manufacturers of various HMD and peripheral equipment are releasing the Software Development Kit (SDK) for the Unity. With this kit, VR machines

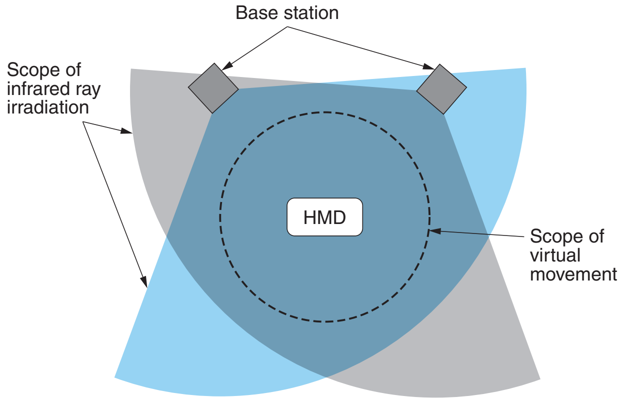


Fig. 2 Image of Base Station Installation

Each sensor is located about 2 meters or more above the floor level. It is tilted downwards by 30° to 45°. Each one irradiates infrared rays within the range of 120 degrees. HDD tracking begins when the action area is contained at least within either range of infrared ray irradiation.

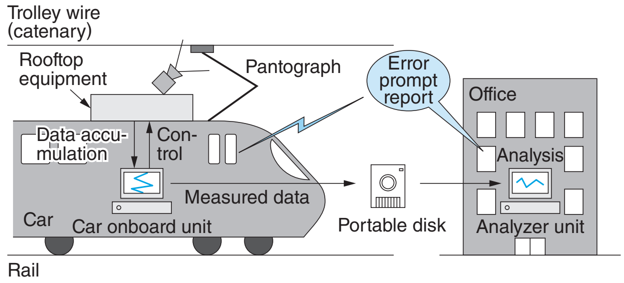


Fig. 3 System Configuration

An outline of CATENARY EYE system configuration is shown. Measured data accumulated in a railroad car are carried in a portable disk and brought into an office.

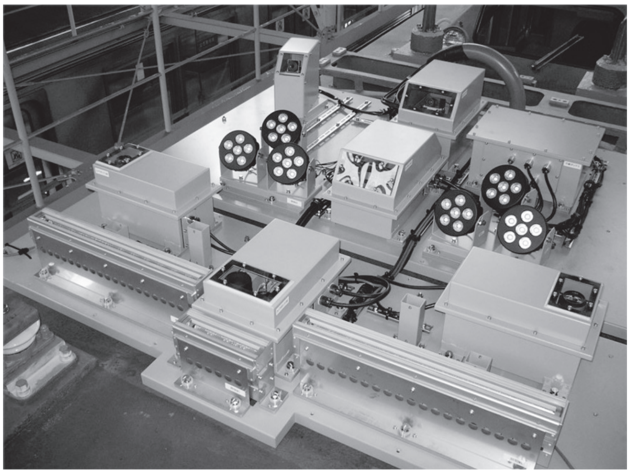


Fig. 4 Example of Rooftop Equipment Configuration

An external appearance of the rooftop equipment is shown. A camera, sensors, lighting, and associated devices are accommodated.

can be easily developed. Since high reality expressions of Computer Graphics (CG) can be easily produced, it is possible to establish a VR system with a heightened sense of immersion.

3 Contents

For the first contents for our VR system, we selected CATENARY EYE from our products related to this plant because this product can provide a comparatively easily understandable VR effect.

3.1 Outline of CATENARY EYE

CATENARY EYE is an inspection system intended to carry out maintenance and inspection of catenary-related systems for electric railroad facilities. Facility status can be analyzed into highly accurate numerical data by using image processing technology with this equipment. It is composed of a rooftop unit equipped with a camera, lighting, and sensors, a car onboard unit to control and accumulate images and data, and an analytical unit installed in an office. Fig. 3 shows a system configuration and Fig. 4 shows an example of the rooftop equipment configuration.

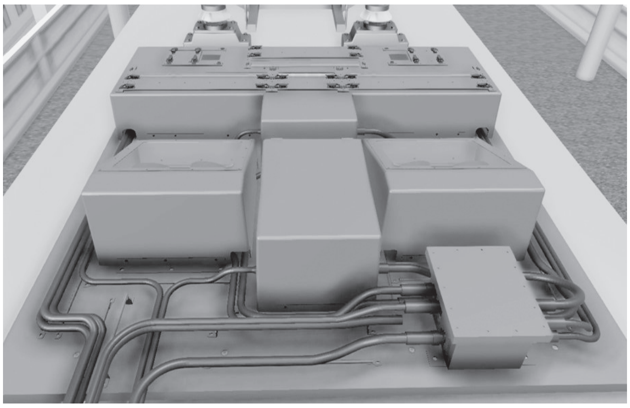
3.2 Virtual Space Inside

Fig. 5 shows an image of the virtual space inside. The inspection car is stopped on an existing railroad track as shown in (a) and the rooftop unit of CATENARY EYE is installed on the rooftop of the car as shown in (b). The touring visitors can observe the rooftop unit sitting in chairs installed on the rooftop of the car. In a virtual space, a view of catenary, pantograph, and surrounding environment is reproduced in a 360-degree mode and the visitors can enjoy the realistic feeling of full immersion. For the experience, an instructor gives oral explanations based on a previously produced scenario.

3.3 Features

For the VR, the absolute coordinates of the HMD and controller are generally detected by the base station and the detected coordinates are regarded as the standard point for the virtual space. The actual amount of movement is detected at the base station and the detected movement is converted into a movement from a standard point in the virtual space for the tracking of the visual field. If the actual position is not identical with the correct VR experiencing position, the objective experiencing position (display = visual field) may be shifted. In

(a) A view of railroad cars installed on the track and environmental circumstances



(b) CATENARY EYE installed on the rooftop of a railroad car

Fig. 5 Image of Virtual Space Inside

An image of virtual space inside of CATENARY EYE is shown.

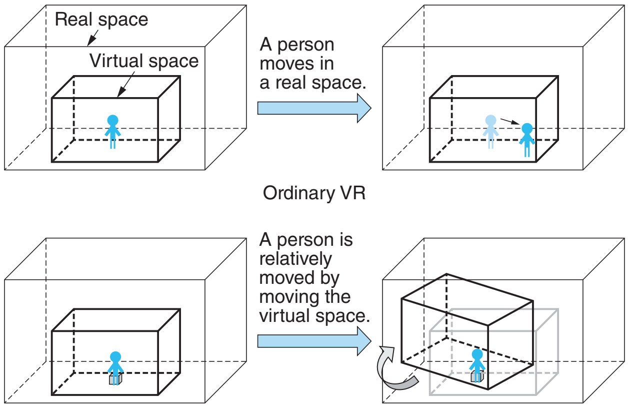


Fig. 6 Movement of Environmental Coordinate System

The absolute position of a VR experiencing person does not change, but the virtual space can be moved. In this arrangement, the VR experiencing person's relative position and field of sight can be moved.

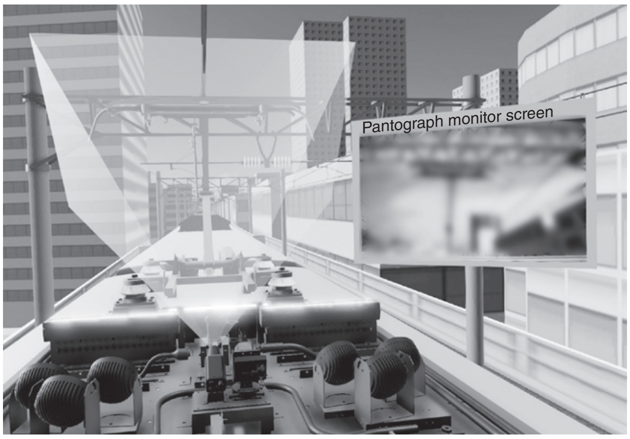


Fig. 7 Display of Overlay

An image taken from rooftop equipment is displayed in the VR space. A camera's viewing angle that cannot be checked realistically is projected in a space.

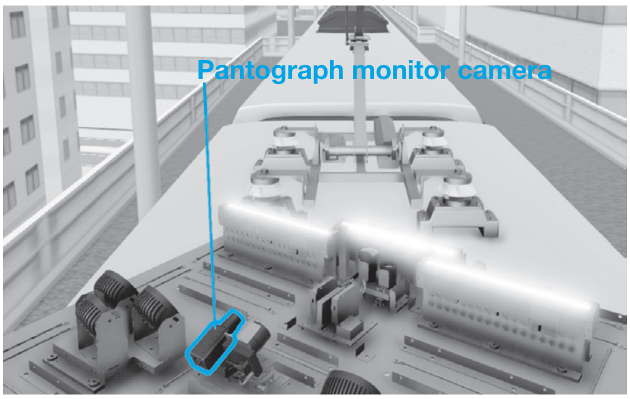


Fig. 8 Display of Equipment Name

The name of a device accommodated in rooftop equipment is displayed in the VR space. These letters are controlled to point at the faces of the visitors. They are made readable even if the rooftop equipment and visitors should move.

the case of an approach adopted for our system, however, the system is established on the assumption that plant touring visitors and commercial talks are made to experience on multiple chairs. To attain a solution, we provided functions to reset the standard point arbitrarily and amend each visitor's position forcedly in the VR to a preset position and direction. By doing so, optimal VR experience can always be achieved without depending on the position of the chair. Fig. 6 shows the movement of the environmental coordinate system. The absolute coordinates of a person are not moved but the virtual space is moved. As a result, the person feels as if there were a mutual movement.

3.4 Displayed Images

Points are introduced below to enable viewing with the VR CATENARY EYE. Fig. 7 shows a display of the overlay. It shows that an image taken with a camera displayed in a virtual space. Fig. 8 shows a view where the name of equipment is dis-

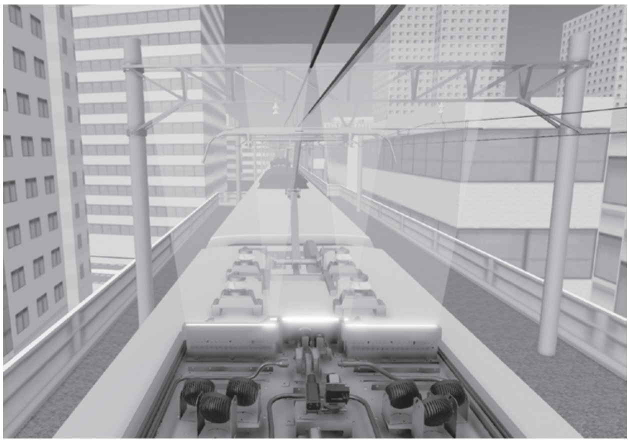


Fig. 9 **Image of Light Irradiation**

The display indicates how the light is irradiated from a lighting device in the rooftop equipment and where the lighting is pointed. An image of the trace of light that cannot be seen realistically is virtually expressed.

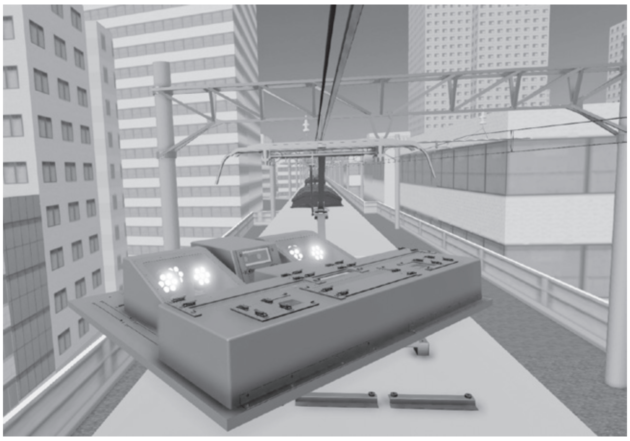


Fig. 10 **Rooftop Equipment Lifting Up**

Since the rooftop equipment is located at the floor level of the visitors, the instructor virtually lifts it up to the eye level of the visitors to help easily see it. The direction of the rooftop equipment can also be adjusted.

played. It is possible to give explanations by showing the name of equipment in the virtual space. Fig. 9 shows an image of light irradiation. The trace of light irradiated from a lighting device is conveyed. Fig. 10 shows a scene where rooftop equipment is lifted. It is possible to adjust the height and direction of the rooftop equipment. Fig. 11 shows a pointer for point of sight. A pointer to show a visitor's point of sight is shown in the field of sight. Fig. 12 shows a multi-language application. The name of equipment is shown in English. Fig. 13 shows a concept model. Even for a cover design without any experience of an actual production, its image can be displayed.

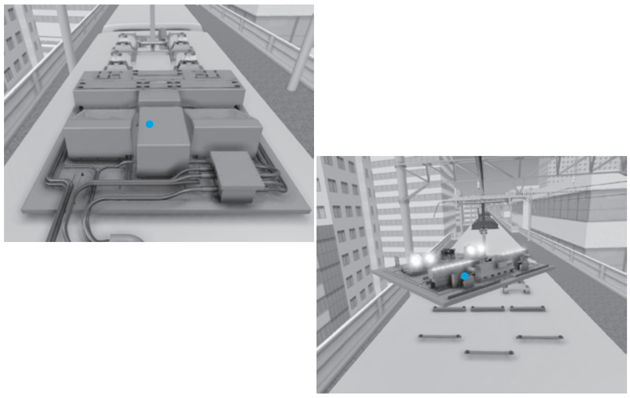


Fig. 11 **Pointer for Point of Sight**

A blue spot is displayed in the center of the VR space. It is used as a communication tool for visitors and the instructor.

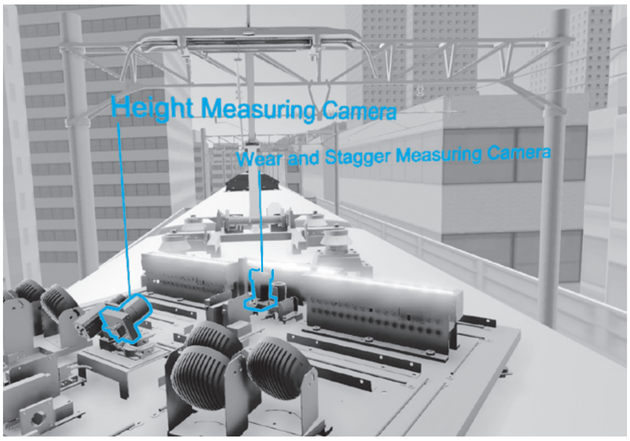


Fig. 12 **Multi-Language Application**

Letters shown in the virtual space can be switched over between Japanese and English.

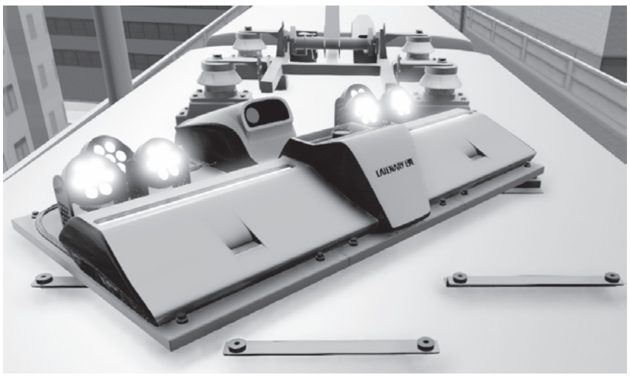


Fig. 13 **Concept Model**

The cover is designed in a streamline shape while maintaining the regular functions. This is a realizable model though there is no former experience of manufacturing it. If VR technologies are effectively used, an image of the installation in a working environment can be viewed without realizing any trial production.

5 Postscript

With the aid of VR technologies, it is possible to give a virtual illusionary experience to a user by showing “something not actually present” as an “illusion that it is present. ” Furthermore, these technologies show “something that cannot actually be seen” in a real space.

Utilizing such features, we have developed and started presenting a VR factory inspection tour system that greatly innovates the conventional factory inspection method. Reactions from both inside and outside of the company are very positive and the degree of satisfaction for factory inspection tour visitors has increased considerably.

From now on, we will try to apply the VR technologies to other fields, such as, design support and instructional education. At the same time, we will work on improving the contents of the VR presentation of our products.

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(Note)

※1. xR (xReality): General terms of technologies such as Virtual Reality (VR), Augmented Reality (AR), Mixed Reality (MR), and Substitutive Reality (SR).