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Development of Augmented Reality-Based Management System for Buried pipe in Operating Nuclear Power plant

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1. Introduction

As the operating life of nuclear power plants increases both domestically and internationally, cases of leakage in buried pipes are on the rise, highlighting the importance of proper maintenance. Existing underground facility management systems have several technical limitations. Most systems rely on standard GPS for location information, resulting in low accuracy that makes it difficult to precisely locate facilities in complex environments[1, 2]. They also depend on 2D drawings, failing to effectively represent the intricate 3D structure of underground facilities. This makes it challenging for field workers to intuitively grasp the condition of underground facilities. To address these issues, this study aimed to develop an augmented reality (AR) based buried pipe management system that can be applied to buried pipes with high management importance.

2. Methods and Results

The AR-based buried pipe management system was developed by comprehensively utilizing various technologies such as AR, Network RTK (Real-Time Kinematic) based positioning, 3D BIM (Building Information Modeling), and visualization of corrosion and damage status through CIPS (Close Interval Potential Survey) and DCVG (Direct Current Voltage Gradient) data. The system configuration is shown in Figure 1.

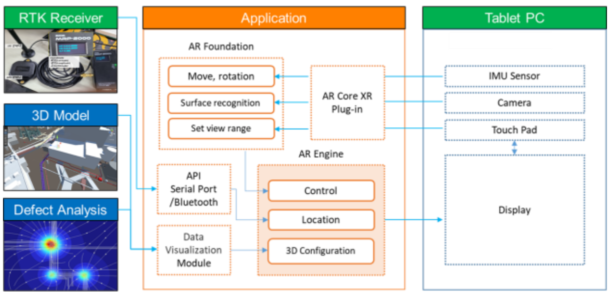
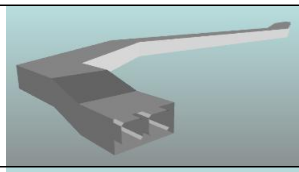
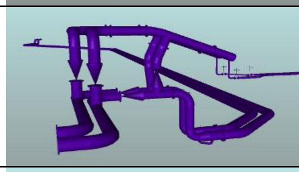
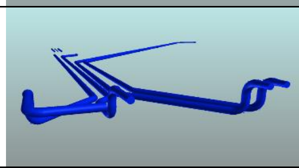
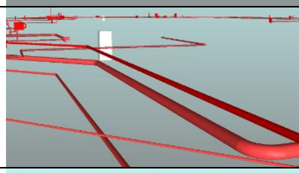
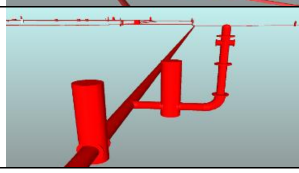


Fig. 1. Configuration diagram of AR-based buried pipe management system

2.1 3D model construction

To implement AR for buried pipes, a 3D model was constructed by comparing and analyzing 2D drawings of the buried pipes in power plant with the actual pipe locations and depths confirmed using GRP (Ground Penetrating Radar) and RD (Radio Detector). The 3D modeling process involved creating 3D design model shapes, inputting attribute information, integrating /converting models, trending/optimizing models, and loading them into AR. This was carried out for five buried pipe systems in power plant. Table I shows the systems and their 3D models.

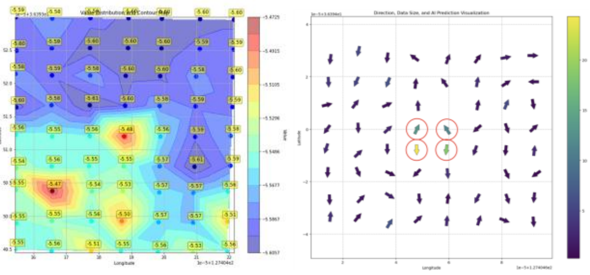
Table I: 3D model of 5 buried pipe systems in power plant

Piping system	3D model
Intake & Discharge Layout for Seawater	
Seawater Yard Piping for Aux. Cooling	
Component Cooling Water Layout for Seawater	
Fire Service Ring Main for Out Side Building	
Hydrant for Outside Building	

2.2 Inspection Data Visualization

The coating integrity of buried pipes is typically assessed using CIPS and DCVG methods. CIPS confirms the overall cathodic protection status of buried pipes, while DCVG detects coating defects. Both methods involve measurements along the pipeline, generating a large amount of data. To facilitate easier data analysis for users, CIPS data was represented as contour maps, and DCVG as current density vectors.

When displayed in AR, they were configured to overlay with the 3D model, enabling intuitive identification of vulnerable areas.



(a) (b)

Fig. 2. Visualization of Inspection Data; (a) CIPS, (b) DCVG

2.3 AR Implementation

Figure 3 shows the 3D model for AR implementation. 3D model objects such as underground facilities, buildings, sites, ground surfaces, and grids were arranged and linked with satellite coordinate information. The objects to be visualized were classified into layers, allowing users to activate or deactivate the visualization of each object according to the situation. Figure 4 illustrates the main functions of the AR system.

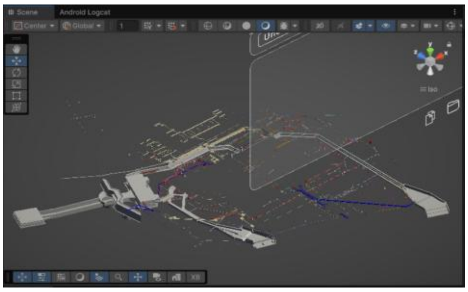
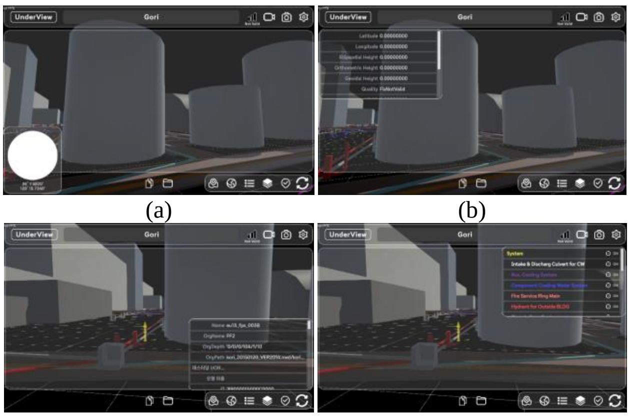


Fig. 3. 3D model for AR implementation



(a) (b) (c) (d)

Fig. 4. Main Functions of Buried Pipe AR System; (a) 2D Map Linkage, (b) Location Information Linkage, (c) Model Attribute Information Management, (d) AR Object Layer Activation Function

2.4 Operational Verification of AR Implementation

To verify the operation of the AR system, a temporary model was constructed for system validation. Figure 5 shows the working screen of the AR system on a tablet PC. It was confirmed that ground surface recognition, pipe model shape implementation, and CIPS and DCVG data visualization were properly implemented.

(a) (b)

Fig. 5. Operation screen of the AR system on a Tablet PC

3. Conclusions

In this study, we developed an AR-based buried pipe management system. By integrating various technologies such as AR, high-precision positioning, 3D modeling, and inspection data visualization, we constructed a system that can intuitively grasp the status of buried pipes. We plan to proceed with verification and performance improvement in actual power plants in the future.

Acknowledgement

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