A Study AR Based Smart Device for Work Management at Plant Construction Sites

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Abstract

One of the difficulties encountered at a plant construction site is frequent changes to design, which causes work overload. This can lead to increased construction costs, delayed progress, inferior work quality and poor productivity due to redundant work among project participants or omission of work.

In this study, we propose a work management system that uses smart devices based on augmented reality technology, which provides real-time information on plant construction so that site workers and managers can reduce wastes and errors, as well as check maintenance information more easily.

Keywords –
Augmented Reality; Smart-Device; Pipe-assembly; DBS(Device Breakdown Structure)

1 Introduction

1.1 Research Background and Purpose

A plant construction project is large in scale than general construction site, and involves complicated planning and processes. At a plant construction site, work data are generated for different stages of work, including architectural work, pipe installation, electricity and other facilities. During construction, massive amounts of data are generated, and management of this data is challenging. Thus, plant construction projects are harder to implement compared to other construction projects.

Various research has been undertaken for efficient management of plant construction, including studies on MIS using QR codes, barcodes, RFID and cloud systems.

However, these technologies entail the problem of redundant work due to delayed processing of real-time data and duplicated systems. As a result, construction time is stretched, and the same work is repeated unnecessarily. Productivity also declines in the maintenance and management stage, as a delay in the resolution of troubled tasks spreads to other related tasks.

In this study, we gather construction site managers' opinions to identify work processes that need improvement and design a plant site information management system accordingly, which can be useful for site workers and managers. At a plant site, a manager often works inefficiently due to poor processing of real-time data and lack of communication between the company and the site office. Moreover, construction workers have difficulty communicating with a manager due to complicated plant design. To address these issues, we apply an AR (augmented reality)-based smart device for pipe installation and construction management, which account for the largest part of a plant project (43%), to identify how to effectively install pipes and manage object data.

1.2 The Scope and Methods of Research

As mentioned above, we propose a management system for plant construction workers and managers that uses an AR-based smart device. At a plant site, workers install pipes based on drawings generated prior to the implementation. However, there is a wide discrepancy between drawings and the actual site, which makes it hard to install pipes. Thus, it is important to establish an information-sharing system between workers and managers to deliver accurate information on the site situation when installing pipes. To this end, we propose using an AR-based smart device.

The method and process of this research is:

(1) Preceding Research Analysis
- Existing review of literature
- Analysis of management characteristic of plant construction and process

(2) Requirement Analysis and Function Derivation
- Figuring out smart device applicability in the

plant field
- Requirement analysis to solve problems

(3) Establishing DBS (Device Breakdown Structure) for optimal plant construction
- Process Analysis at Plant Site
- Analysis of maintenance Work at Plant Site
- DBS Proposal by Different Work Processes

(4) AR Technology at Plant Construction Site

2 Research Trend

2.1 Literature Review

Since the mid-2000s, active research has been undertaken to identify how to use various IT technologies to improve plant construction, specifically, to shorten construction time, reduce costs, ensure flawless construction, engage in accident-proof planning, enhance work predictability, eliminate wastes, improve productivity, and reduce maintenance costs.

Most studies on plant construction and management have been limited to proposing conceptual methodologies or solving logistics issues (e.g. delivery of materials). There are few studies on how to generate and utilize real-time information on pipe work or how to discover errors.

Table 1 Existing research

Area of management	Research subjects
Construction	Ontology-based BIM modeling; AR-based system framework 4D tools for greater efficiency in site management
Site condition	Use of smart phone to improve management process; visualization of project information using real-time data sharing and management, wireless communication; and augmented reality
Safety	New 4D safety management and monitoring system ‘C-RTICS2’ for more efficient construction and communication among work partners Behavior-based preventive safety system, visualized management with VCS (Virtual Construction Simulation System)
	Note
Construction	Marker-based AR: Research on identification of objects, selection of marker type, marker detection, and marker-less AR technology
Site condition	Wearable device for real-time work coordination Wearable device; Cloud system for massive data management
Safety	Set apart in terms of device and visualization method, while similar in technology for communication between office and construction site Partly applicable to safety management in terms of carrying out preventive safety management in visualized form

2.2 Plant Construction Management

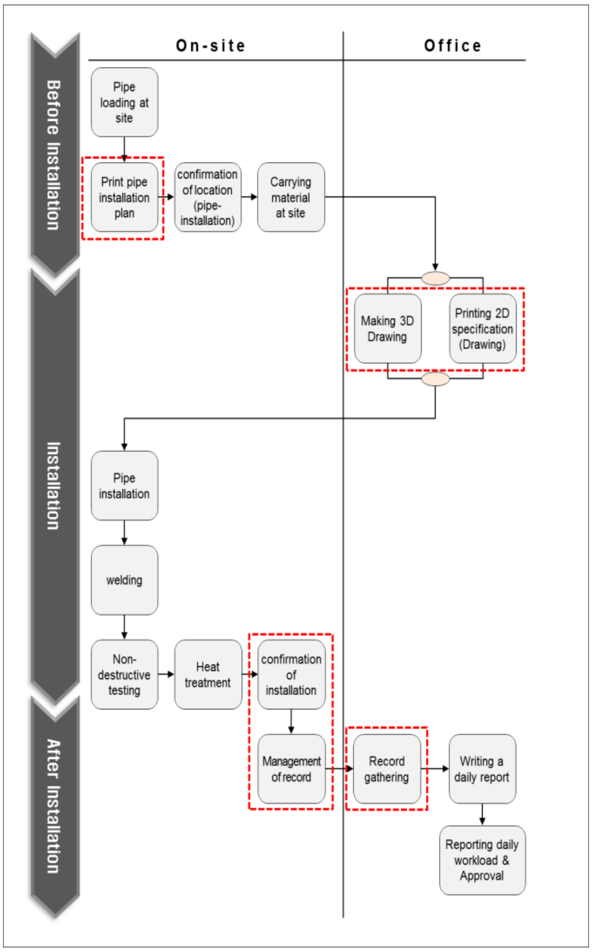

Figure 1. Pipe construction process

At a plant construction site, pipe installation can be divided into three stages: pre-installation, installation and post-installation.

In the first stage, materials are delivered and detailed 2D drawings are produced, based on which the site is surveyed, and 3D drawings are produced.

In the installation stage, workers install pipes based on the drawings. In the after-installation stage, managers and workers carry out maintenance work.

In this process, workers and managers do not fully share information, and it is hard for a manager to accurately explain the installation process to workers based on drawings. To resolve this difficulty, we propose a new process and system.

3 Analysis of plant workers' needs

Moon [16] conducted an interview with and surveyed the project sites of S company, one of the country's leading construction companies, and found out that workers needed smart applications for construction assistance, data confirmation and checks and guidelines, particularly for communication support and progress management (Figure 2.).

He showed that, at plant construction sites, workers need to have a smart device system to share information during the design and implementation processes.

Table 2 Applicable work territories

Direction	Contents
1	Construction Assistance App.
2	Data confirmation and check App.
3	Data input App.
4	Guideline App.
5	Communication support App.
6	Progress management App.

At a plant site, workers need drawings and related data to handle materials and make necessary installations.

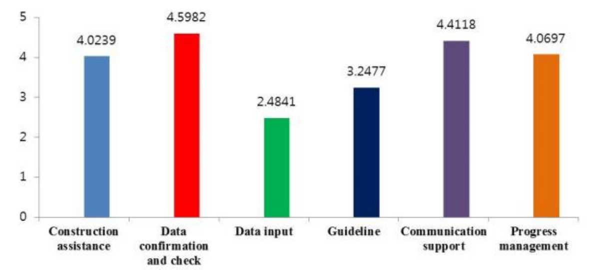

Figure 2. Overall result

These data are generated in different forms and communicated to workers in visualized forms. The alteration of certain data affects other data and generates new information. Using smart devices and applications could support this process

4 Establishing DBS(Device Breakdown Structure) for optimal plant construction

4.1 Process Analysis at Plant Site

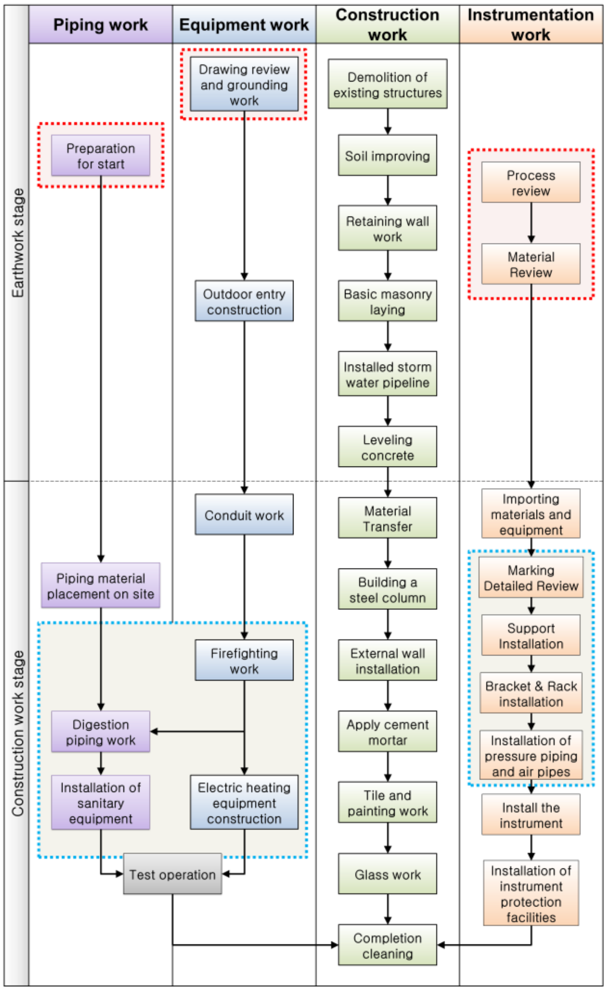

Figure 3. Construction work process of plant site

We analyzed the construction process at a plant site to identify areas of work in which the use of a smart device can be applied. The analysis was done for earth work and architectural work, specifically for processes such as architectural work and electricity, pipe and facility installation.

The analysis results showed that, for earth work, it is important to convert materials data and drawings into a 3D model to help workers' understanding of the process. For architectural work, it is important to produce information on materials and processes that are in progress or completed, and to provide a 3D model based on augmented reality for review.

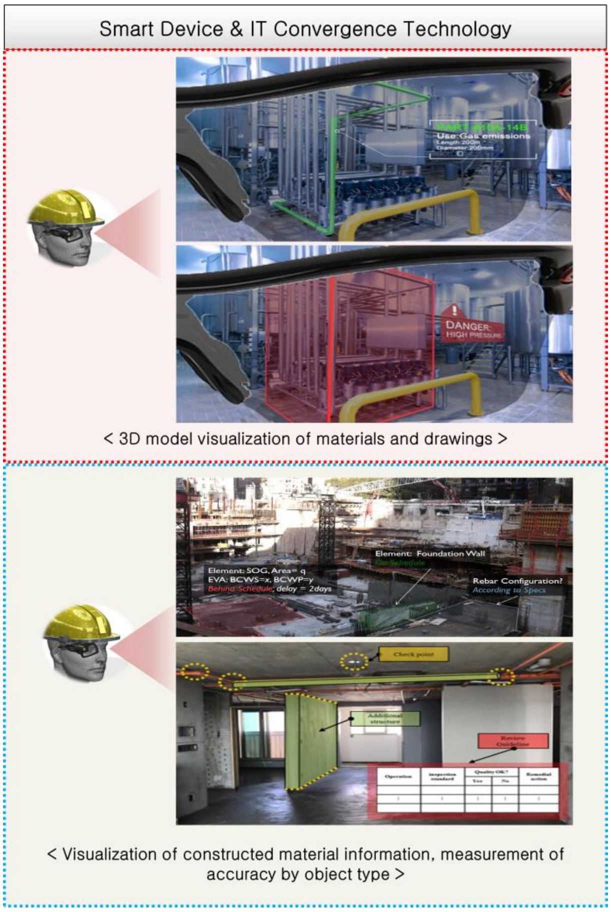

Figure 4. Smart device & IT convergence technology in plant site

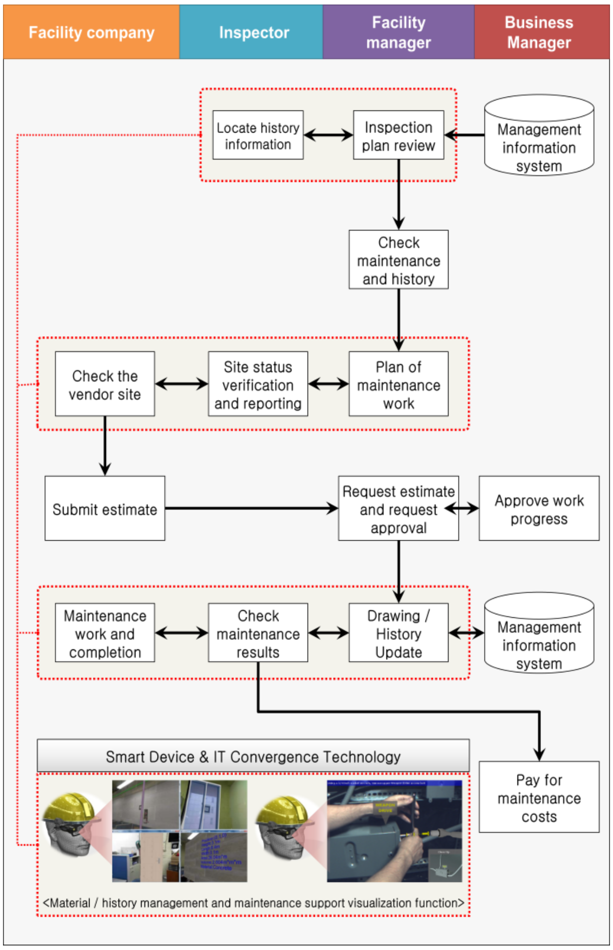

Figure 5. Maintenance process of plant site

4.2 Analysis of maintenance Work at Plant Site

The analysis results showed that facilities management companies, inspectors and facilities managers need a maintenance system that uses an AR-based smart device to inspect, maintain and repair plant facilities.

More specifically, tasks that could use an AR-based smart device included planning and review of facilities maintenance, updating drawings/records for the facilities management company, managing records and site locations confirming maintenance results for inspectors and conducting site check and maintenance work for facilities managers. Smart devices can be used to track records of materials and visualize related information.

4.3 DBS by Different Work Processes

Based on interviews and analysis of plant processes, we identified smart devices suitable for various participants of a plant construction project, that is, plant constructors, architectural workers, facilities supervisors and facilities managers. Then we examined various functions of smart wearable devices that can be used to process data generated by site workers.

Our investigation showed that watch-type, band-type, and glass-type devices are suitable for a plant construction project. As for device sensors, bio information, GPS/NFC, accelerometer, visual information and Bluetooth are applicable to plant construction. We matched site workers' needs with different types and functions of smart devices so that the workers could choose an efficient device.

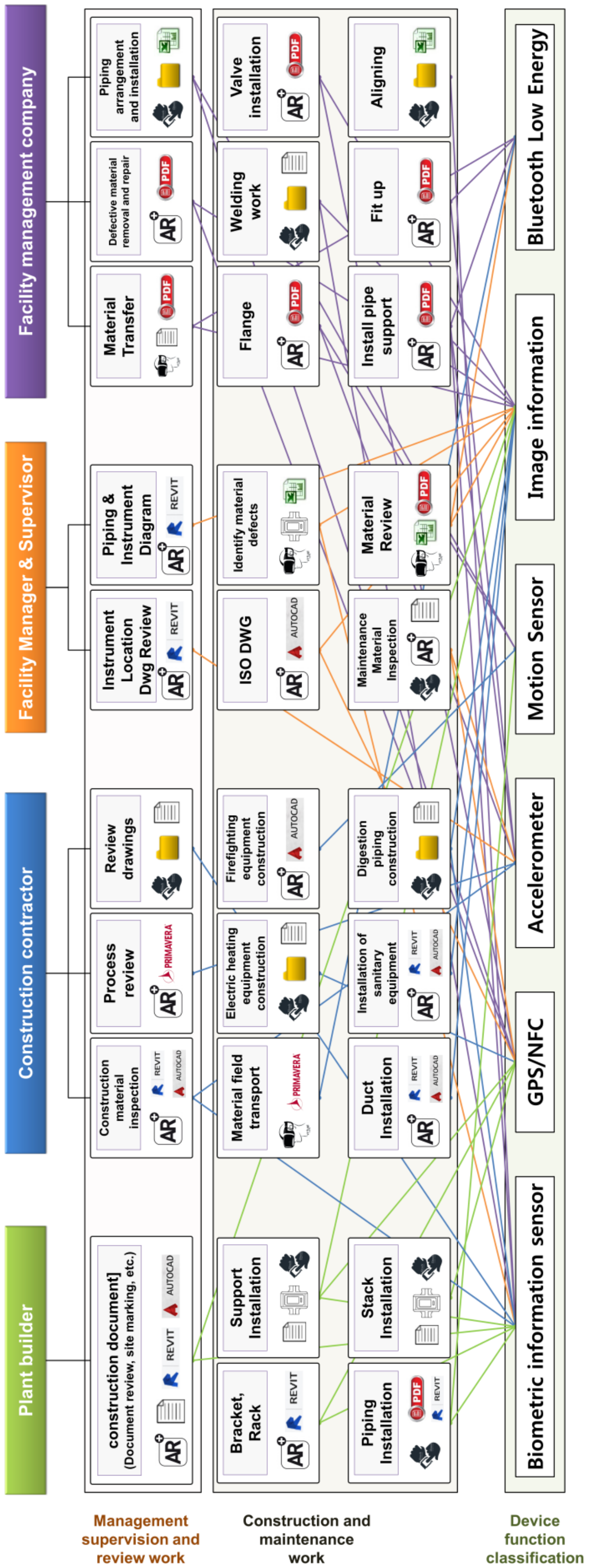

Figure 6. Device breakdown structure

5 AR Technology at Plant Construction Site

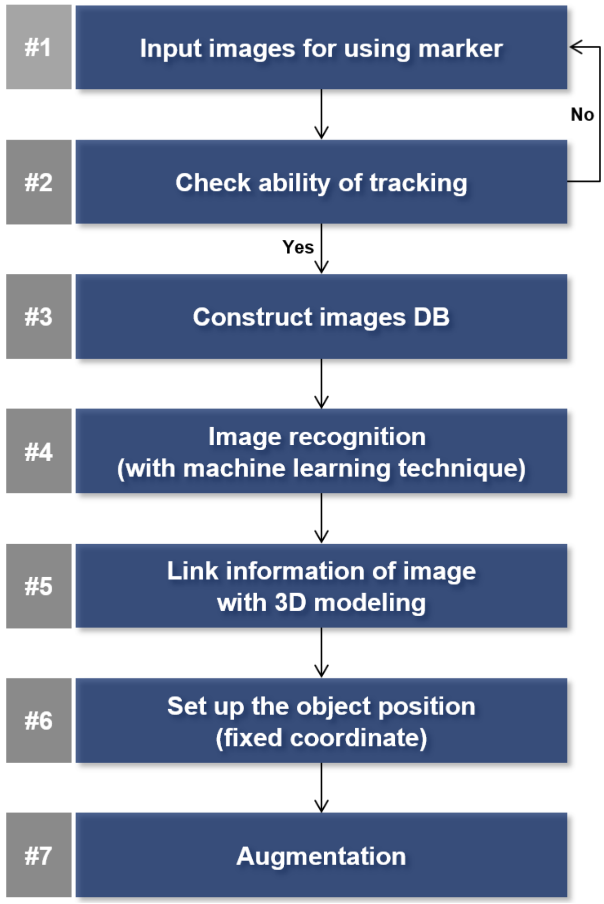

Figure 7. Augmented Reality System Diagram

To apply AR technology at a plant construction site, we conducted an experiment (See Figure 7). First, image input was made to use marker. Second, to check that images were recognized as markers by the smart device. If the image was recognized as a marker, save it in DB. or if not, input the image again. Third, image data of useful information were collected to generate an AR marker file. Fourth, the stored image data is used to improve the object recognition rate through machine learning techniques. Fifth, the marker was linked with 3D modelling/images, and sixth, the position of the object was set on a smart device display. Lastly, AR data were generated accordingly for use at a plant site

Through this process, the worker uses the camera of the smart device at the plant construction site to recognize objects from various angles as markers, and links objects and 3D modeling information.

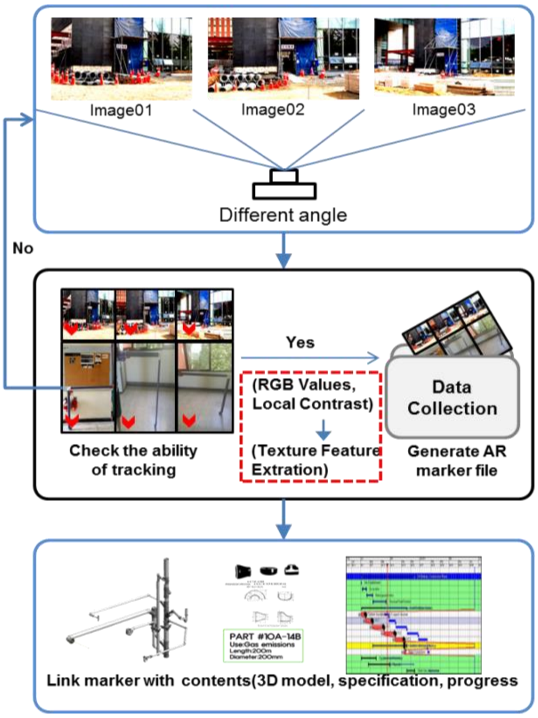

Figure 8. Images for using marker

6 Conclusions

In this study, we analyzed traditional processes of plant construction, conducted interviews to identify difficulties and problems at plant construction sites, and explored the applicability of smart device at plant sites. To this end, we analyzed work processes at plant sites, examined maintenance work, established DBS (Device Breakdown Structure) for various participants of a plant construction project and examined how to apply AR technology.

Regarding work processes at a plant site, we examined different stages of a construction project and identified technological elements that can be applied to earth work and architectural work. For analysis of maintenance work, we identified areas of work that need visualized information. Additionally, we established DBS for site participants and examined how to adopt marker-based AR technology at a plant construction site.

Based on the analysis of plant construction processes and maintenance work, smart devices can be adopted at a plant construction site according to DBS of different work areas, and AR data can be generated through marker-based image links. Using these data, workers can check information and acquire better understanding of the work process. Moreover, a Cloud system may be introduced for real-time information sharing. Based on these findings, we plan to conduct further research on marker-less image tracking using deep-learning technology.

Acknowledgements

This work is financially supported by Korea Ministry of Land, Infrastructure and Transport(MOLIT) as 「Smart City Master and Doctor Course Grant Program」

"This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MSIP) (No. NRF-2016R1D1A1B03935868)."

This research was supported by a grant(17CTAP-C133224-01) from Infrastructure and transportation technology promotion research program funded by Ministry of Land, Infrastructure and Transport of Korean government.

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