Journal of Engineering and Applied Sciences 13 (3): 756-759, 2018
ISSN: 1816-949X

Efficient Management System for Underground Power Facility Utilizing AR

[1]Juheon Lee and [2]Taehyun Jeon
[1]Department of Information Technology and Media Engineering,
[2]Department of Electrical and Information Engineering,
Seoul National University of Science and Technology, 01811 Seoul, Korea

Abstract: Augmented Reality (AR) is an immersive media technology with which information about the surrounding environment is overlaid on the real world. It can be utilized in various types of application areas. In this study, we discuss an AR based system which provides the information about electric line route, equipment condition and operation status of underground power facilities to smart devices in the field. This system consists largely of an AR operation server and a smart device. In this system, the operational status and event information, the electric line route information and the sensor data can be viewed as a form of the AR image using cameras on site. With this information it is expected that the rate of service interruption can be reduced through the systematic management of the power facilities.

Key words: Augmented reality, underground power facilities, power management, geographical information system, immersive media technology, electric line route

INTRODUCTION

Distribution facility is one of the electric power facilities which supplies electricity from substations to customers. It is divided into the overhead power facility and the underground power facility. For the contstruction of overhead power facilities, electric poles are built and electric wires are placed on them. For underground power facilities, ducts, manholes and tunnels are constructed under the ground and then electric wires are placed. Although, the construction cost of underground power facilities is relatively high, the number of such facilities in the metropolitan area is steadily increasing due to the better exterior and reliability than overhead facilities (Jung and Seon, 2009). However, it is difficult to monitor their condition and to perform the prompt inspection when the failure occurs, since underground power facilities are installed below the ground level where the accessibility is relatively low. The change of surrounding environment such as roads and buildings and the burial of other underground utility facilities for communication, gas and heating could lead to difficulty in maintenance of power facilities. In addition, the systematic management of such system can not be achieved with the conventional method, since, it is in general relies on the inspection history and the memory of the operator in the workplace (Jung and Seon, 2009). With the increase of underground power facilities there is a limitation to carry out the manual inspection and management by workers only. In order to improve the management process and to prevent accidents, it is necessary to deal with the information inconsistency due to the limitation in the manual inspection and management.

Augmented Reality (AR) is an immersive media technology that enhances physical and intellectual capabilities by providing real-time information that combines visual and virtual environments (Ha *et al*., 2016). The AR can be utilized as various types of media in reality. In the AR, the burden of 3D modeling is reduced compared with the virtual reality technology and it can be used in more extensive application areas. On the other hand, there are technical difficulties to provide information in real time in response to user’s movement and changes in surrounding environment (Shin *et al*., 2010). Implementation of AR technology requires the following essential hardware and software components. The GPS device and the gravity sensor transmits and receives location information. The Geographic Information System (GIS) stores the detailed data according to the information. The application software and the smart device display the detailed data on a real background.

In recent power systems, the information and communication technology is widely used to ensure high quality and stability of power supply. In this study, we discuss a system to manage underground power facilities using the mobile AR technology. As mobile devices such

Corresponding Author: Taehyun Jeon, Department of Electrical and Information Engineering,
Seoul National University of Science and Technology, 01811 Seoul, Korea

as smart phones and tablet PCs are introduced in our daily lives, various types of services with mobile AR have been released (Shin *et al*., 2010). Related research works have been conducted in the field of electricity where possible application areas are introduced, although detailed system descriptions are not discussed (Chae *et al*., 2011; Lee *et al*., 2008). The main purpose of this study is to discuss a system which enables the transmission of the information to the smart device used by the worker as a form of AR focusing on the underground power facilities. The information is provided by GIS on the internal network and the Internet of Thing (IoT) sensor attached to power facilities (Bottaccioli *et al*., 2017). Through this study, it is expected that we can achieve a high efficiency in the inspection and management process for underground power facilities. This study assumes that the development system is linked to GIS operated by internal network and IoT gateway.

MATERIALS AND METHODS

Underground power facility management system

System overview: Figure 1 shows the hardware configuration of the power facility management system using AR. This system consists of AR operation server and the smart device (terminal device). It should be linked with GIS-based power information system operating on intranet and research management system that deals with various research status. Also, it should be associated with a gateway that acquires data from IoT sensors monitoring the status of the power equipment. The AR server uses TCP/IP as a linkage protocol between the intranet information system and IoT gateway.

The field worker's smart device and AR server should be connected to wireless network (3G, 4G, WiFi, etc.). In order to operate the system without interruption, the information of the GIS-based power information system and the field power facilities must be matched. Table 1 summarizes the main features of the communication standard candidates which can be used for the data transmission between IoT gateway and sensors. Various wired and wireless communication protocols such as KS-PLC (Korea, high-speed PLC), HPGP (US, medium-speed PLC), Wi-SUN, ZigBee and LTE can be used to monitor the operation status of underground power facilities (Anonymous, 2015, 2012, 2010; Korhonen, 2017).

The configuration of the software module of the underground power facility management system utilizing AR system is shown in Fig. 2. The AR system acquires database and sensor information through the power information system and IoT gateway. Software modules of the AR system mainly consist of the AR management and the AR engine. The AR management block consists of the connection manager, the device manager and the database manager. The AR engine consists of the management service, the information service and the contents service. The management service provides the

Table 1: Communication standard candidates for IoT sensors and gateway

Standards	Frequency band	Data rate	Main features
KS-PLC	2~24 MHz	24 Mbps	Korean high-speed PLC technology (2005) International standardization (IEC) registration (2009)
HPGP	2~30 MHz	10 Mbps	Medium speed PLC technology (2000s)
Wi-SUN	900 MHz Band	200 kbps	Short-range wireless communication by Wi-SUN Alliance (2010)
ZigBee	2.4 GHz band	250 kbps	4 GHz band short-range wireless communication (2000s) ZigBee alliance established standardized test certification system
LTE	700 MHz ~ 5 GHz band	>10 Mbps	Excellent performance and installation convenience Cellular network usage fee required

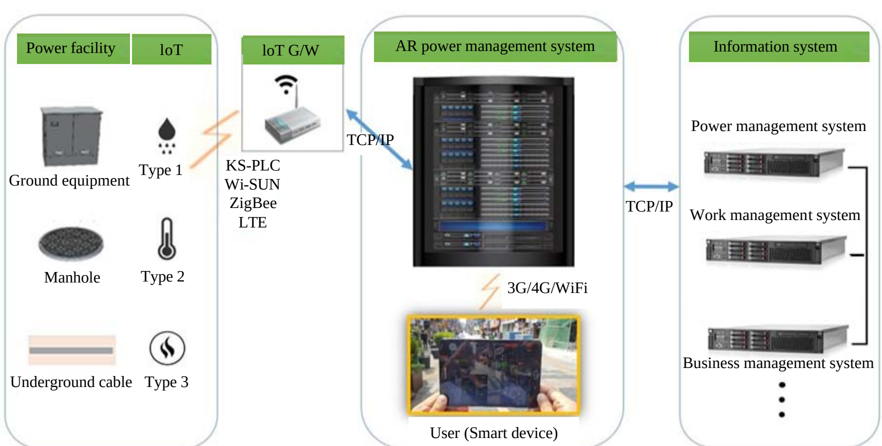

Fig. 1: H/W configuration of underground power facility management system

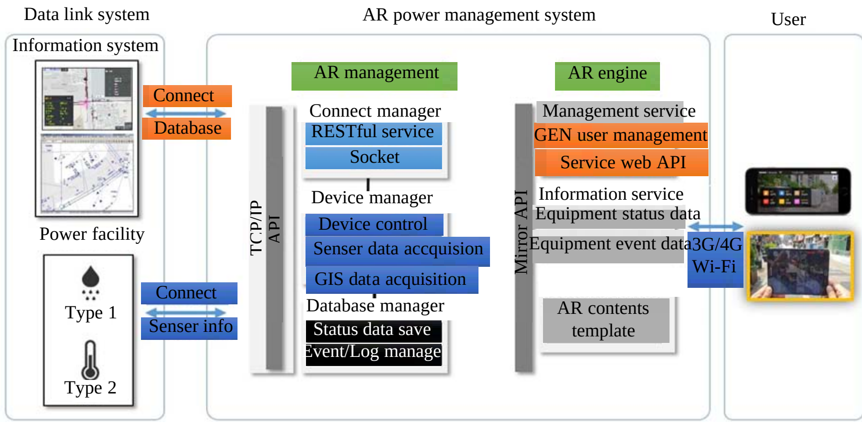

Fig. 2: S/W module configuration of underground power facility management system

functions of general user management and service web. The information service displays event information about state and unusual information acquired through IoT sensors for the power facility. The contents service provides the basic template of AR information to a smart device of the users in the field. The AR server and the user's smart device can be configured according to the required security policy. Mobile security and terminal authentication security policy should be applied. Only the smart devices with pre-authorized IPs can transmit and receive the data to and from the AR server through TCP/IP. The hardware required to build the AR system includes a server computer and a tablet PC. The software required for the AR server includes the server engine, the GIS engine and the data conversion tool. The AR mobile application software is installed in the smart device. Mobile GIS and security programs are required for both AR servers and smart devices.

RESULTS AND DISCUSSION

Main features of system: This system provides the status of underground power facilities as a form of AR information through the smart device. It visually displays the status of the underground power facility and the route of the underground power cable. The GPS information and 3D visualization technologies are used to implement the power cable information map. Additional information is provided when the corresponding area or equipment is selected through the map service. In other words, a synthesized image of a virtual image such as the drawing or the specification are displayed on a real object when a specific power facility is selected through a real smart device. The main functions of this system include user authentication, facility recognition according to location (direction) facility detail inquiry, map view and sensor

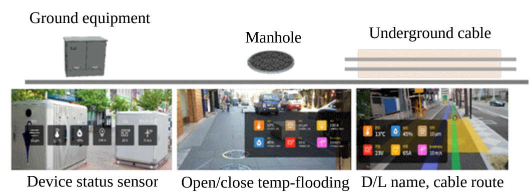

Fig. 3: Application examples of power facility management system utilizing ARP

information provision. As shown in Fig. 3, the operator can easily obtain the information on the operating status and surrounding conditions of underground power facilities using AR technology. Through AR smart devices, users can check the location and route of ground equipment, manholes, underground power cable and operation status of power facilities.

A 2D map or satellite map can be used to identify the operator's current location and surrounding facilities. It is also possible to check the status information provided by the IoT sensor attached to the power equipment. That is it can monitor various real-time information provided by IoT sensors attached to the equipment such as temperature, humidity, voltage, current and other environmental information inside the device.

CONCLUSION

In this study, we discuss a system which can provide the information of installation condition and operation status of underground power facilities to smart devices of workers in the field. This system provides the route of the underground power cable, the facility specification and the sensor acquisition data such as power cable, tunnel, manhole and ground equipment. By providing AR image of underground power facility location and underground cable path to operators it is possible to manage the power facilities more efficiently and protect the facilities from various threats. In addition, it is expected to help to prepare prompt countermeasures in response to emergencies and incidents of underground power facilities on site.

REFERENCES

Anonymous, 2010. 1901-2010-IEEE standard for broadband over power line networks: Medium access control and physical layer specifications. IEEE, New York, USA. http://ieeexplore.ieee.org/document/5678772/.

Anonymous, 2012. 802.15.4g-2012-IEEE standard for local and metropolitan area networks-Part 15.4: Low-Rate Wireless Personal Area Networks (LR-WPANs) amendment 3; Physical layer (PHY) specifications for low-data-rate, wireless, smart metering utility networks. IEEE, New York, USA. http://ieeexplore.ieee.org/document/6190698/.

Anonymous, 2015. 802.15.4-2015-IEEE standard for low-rate wireless networks. IEEE, New York, USA. http://ieeexplore.ieee.org/document/7460875/.

Bottaccioli, L., A. Aliberti, F. Ugliotti, E. Patti and A. Osello *et al.*, 2017. Building energy modelling and monitoring by integration of IoT devices and building information models. Proceedings of the 2017 IEEE 41st Annual International Conference on Computer Software and Applications (COMPSAC) Vol. 1, July 4-8, 2017, IEEE, Turin, Italy, ISBN:978-1-5386-0367-3, pp: 914-922.

Chae, C., N. Back, D. Kim and N. Jung, 2011. A study on power equipment maintenance using augmented reality. Korean Inst. Electr. Eng., 7: 1993-1994.

Ha, G., S. Shin and H. Yun, 2016. VR platform for realistic experience. Electron. Eng. Korea, 11: 1030-1033.

Jung, J. and S. Seon, 2009. A study on the cause of the fault on underground distribution line. Korean Inst. Electr. Eng., 7: 302-303.

Korhonen, J., 2017. Evolved universal terrestrial radio access (E-UTRA) and evolved universal terrestrial radio access network (E-UTRAN): Overall description; Stage 2. Nokia Corporation, Espoo, Finland.

Lee, K.H., J.M. Lee, D.G. Kim, Y.S. Han and J.J. Lee, 2008. Development technology of vision based augmented reality for the maintenance of products. Korean J. Comput. Des. Eng., 13: 265-272.

Shin, C.S., T.J. Ha, K.Y. Kim, W.W. Lee and Y.H. Lee *et al.*, 2010. Ubiquitous virtual reality framework and its application for fostering sustainable content ecosystem. J. Inst. Electron. Eng. Korea CI., 47: 123-134.