INTERACTIVE COMMUNICATION PLATFORM FOR CONSTRUCTION MANAGEMENT USING MOBILE COMPUTING AND AUGMENTED REALITY

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Abstract

Construction projects involve numerous stakeholders and participants. Their communication processes can often times be tampered by ineffective communication systems. With the advent of mobile computing, the quality of communication between project stakeholders and participants could be significantly improved. In this study, for the effective communication among construction participants, an interactive communication platform is presented through integrating a location-based augmented reality and a mobile computing technology. The location-based augmented reality presents rich virtual construction information on a real world and the mobile device offers interactive and ubiquitous computing environment for construction engineers. This interactive communication platform is expected to advance the existing information management process so that field engineers can get all the necessary information on a real-time basis.

KEYWORDS: Augmented Reality, Construction Management, Green Construction, Mobile Computing.

INTRODUCTION

For a long time, the construction industry has talked about the fully integrated information system for effective construction management on site. With the advent of intelligent mobile devices such as smart phones, the need to establish a strong mobile communication platform for construction management is now more than ever.

The main purpose of the proposed study is to develop an augmented reality-based mobile computing platform in which sustainable construction processes are secured. The proposed platform is implemented in a mobile computing device, and is the core medium through which construction information are acquired, processed, analyzed and transferred. The platform is expected to significantly improve the existing construction practices, resulting in increased productivity and reduction of greenhouse gas emission.

LITERATURE REVIEW

Studies have been conducted to embrace a range of mobile devices, such as PDAs (Personal Digital Assistants), cellular phones, and smart phones, in the construction management process (Peña-Mora and Dwivedi, 2002). Shin et al. (2008) used PDAs to improve productivity in the process of apartment finishing. Kim et al., (2008) used PDAs for quality control process at an apartment construction site. Lipman (2004) implemented a system where PDAs contain 3D CAD information, such that the construction structure could easily be referred to. Wang (2008) developed an inspection system where information stored on RFID (Radio Frequency Identification) tags could be checked with the use of PDAs.

These previous studies have opened the way to incorporate mobile computing technologies into the regular construction management processes. Now with the strengthened capacity of mobile devices, much more advantages can be obtained. For example, GPS (global positioning system (GPS), gyroscope, accelerometer, tilt sensor, and the wireless networking technology built in the mobile device enables a new generation of new construction application such as location-based, customized work order and execution.

PROPOSED MOBILE PLATFORM FOR INTERACTIVE COMMUNICATION

The proposed mobile platform for interactive communication has four main modules: interactive visualization module, progress monitoring module, collaboration module, and green construction module. The following sections explain in detail the four main modules. Note that figures 1 to 4 are simulated pictures that show the proposed system when completed.

Interactive visualization module development

The interactive visualization module enables the mobile computing device to display the augmented reality image that includes not only the real scene of the construction site but also a virtual image. The virtual image indicates whereabout of construction resources such as construction equipment and material, and the virtual image, once clicked, can show detailed information about the construction resources, which are required for effective construction management.

Figure 1 illustrates the interactive visualization module. The user, when using a camera function of the mobile device, can see the construction site scene on the screen of the device. A virtual image, is then placed on the corresponding real image portion, implying that there is information about the particular material. In figure 1, the image on the screen of the mobile device shows a crane moving a stringer (steel component). The user can then touch the virtual

image tag titled "stringer" to find out the information shown in the snapshot of the user interface. The user interface is displaying such information as component ID (Identification), weight, material type, dimensions, delivery date, and installation. Installation information tells the user whether or not the stringer is installed on the site. The user can interact with the mobile device to know or update the material-related information. The same type of information exchange can occur for the crane itself. It is worth noting that image processing, RFID-based system, and GPS can help to put the virtual image mark on the real scene of the construction site.

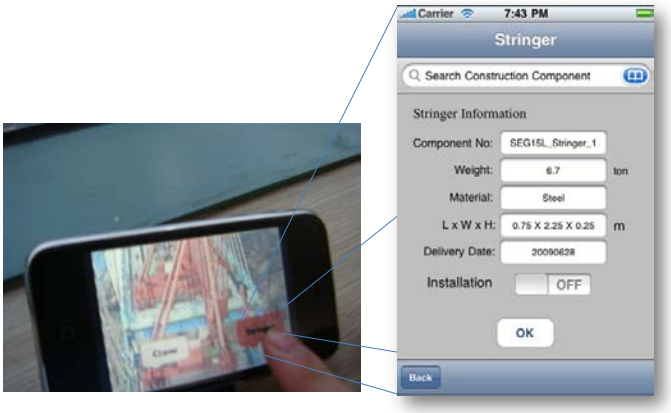


Figure 1: Interactive visualization module

Progress monitoring module development

The progress monitoring module enables the mobile computing device to acquire the construction site images and analyze them using various digital imaging technologies. The analyzed image will allows for automated progress monitoring that can tell the site superintendents the current level of project progress. Imaging technologies such as the one seen in Wu et al. (2010) can be used for this module.

Figure 2 illustrates the progress monitoring module in case of a bridge construction. The user interface is displaying the progress information about the installation activity for a steel edge girder. Such information as activity ID, segment number, component ID, start date, end date, critical path, and progress rate. Segment number indicates in which segment of the bridge the edge girder is being installed. Critical path means whether or not the particular activity is on the critical path. Progress rate shows the accumulated progress level information.

(1) Construction site image acquisition

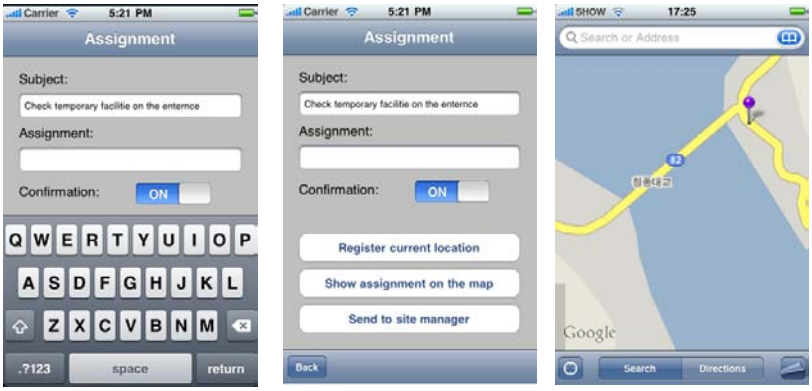
(2) Management of current construction process

Figure 2: progress monitoring module

Collaboration module development

The collaboration module in the mobile computing device enables effective exchange of site information among the project participants. The location information available in the mobile device will allow for customized work order, report, and collaboration.

Figure 3 illustrates the collaboration module. The left and the middle interfaces are used to give work order to the site engineers. The interesting feature of this module is that the work order can be assigned to the field engineers with the location information. Figure 3 shows the map that pinpoints the location where the work order is executed. This type of work assignment that uses location information will minimize unnecessary misunderstandings of the project participants.



(1) Input assignment

(2) Input and transfer location-based information

(3) Pin-point on the map

Figure 3: Collaboration module

Green construction module development

The green construction module enables the construction engineers on site to estimate the amount of greenhouse gas emission of construction materials and equipment. This module will motivate and help the engineers in proposing new construction methods for reduced greenhouse gas emission.

Figure 4 illustrates the green construction module. At any time during the construction, the user can estimate the current level of carbon dioxide emission caused by the construction. As shown in figure 4, the total carbon dioxide emission graph resembles the S curve of cost expenditure. This graph was obtained from the previous study (Kim and Kim, 2009). This module will awaken the construction engineers to the need of more environmentally friendly construction practices.

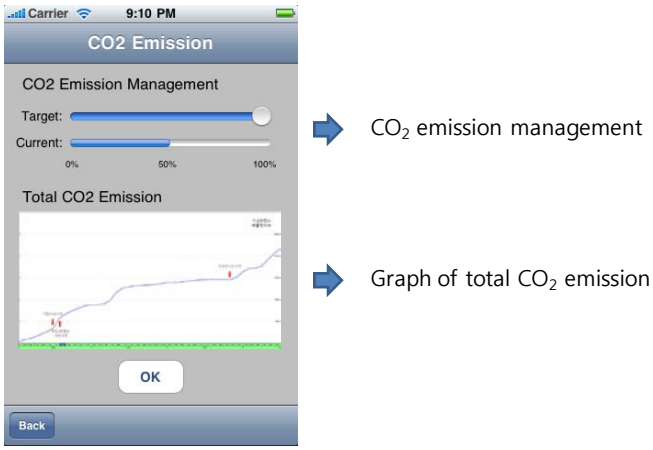


Figure 4: Green construction module

CONCLUSIONS AND RECOMMENDATIONS

This paper presented a mobile platform for interactive communication in construction projects. The platform consists of four main modules: interactive visualization module, progress monitoring module, collaboration module, and green construction module. Each module was explained with an illustrative case and figure.

The proposed platform is expected to pioneer the way the mobile computing technologies will change the paradigm of the existing construction processes. The green construction module can help to establish more eco-conscious construction practices, such that sustainable, environmentally friendly are secured. The improved construction efficiency, along with the reduced emission of greenhouse gas, will change the tarnished image of the construction industry.

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