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A 3D surface modeling system for intelligent excavation system

Myung Jin Chae *, Gyu Won Lee, Jung Yoel Kim, Jae Woo Park, Moon Young Cho

Department of Construction Engineering and Management, Korea Institute of Construction Technology, 2311 Daewha-dong, Goyang-Si, South Korea

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ABSTRACT

The purpose of this study is to develop a mobile 3D work environment recognition system for civil earthwork. A mobile 3D laser scanner system and software have been developed in this research. This study is a part of Intelligent Excavation System (IES) project that develops an autonomous earthwork system. Work environment data acquisition and recognition is the first stage of the project. In order to optimize and automate the 3D scanning process, Mobile 3D Imaging System was designed, and an actual earthwork environment was scanned and processed using the developed system. The paper describes (1) the selection of the most appropriate scanner for the construction field, (2) development of vehicle mounting station for the scanner, (3) development of the customized scanner controller software, and (4) development of automated mesh creation and registration of multiple scan data.

1. Introduction

1.1. Backgrounds and purpose

Productivity improvement in construction process has been considered very difficult task because of the many uncertainties and the many activities that must involve human inputs and hard to get automated. However, this means that there is lots of rooms for improvement as advanced tools and equipment are being introduced to the market. This paper introduces an alternative method for typical surveying activities for earthwork task in civil work. Total station that has a laser technology measuring distance is probably the most commonly used surveying equipment in the field. For it's easy to use, cost effective, and with relatively accurate survey results, total station is a popular surveying tool. However, developing a CAD drawing for about 100-by-100 meter earthwork site using total station would take 2 days in the field and several hours of CAD drawing work. Recent technology, 3D scanners (or more generally speaking, 3D imaging system) can be used in place of total station but not much field test and application have been developed.

In this research, a 3D scanner has been chosen that would fit in the construction field, and is customized for earthwork environment data acquisition. The scanner is mounted on a mini-van, so the scanner can scan from the top of the van. Software has been developed to control the scanner and process the obtained data.

Hardware add-ins and software development are for the optimization of the earthwork environment. This research and development is part of the Intelligent Excavation System (IES) project that aims automated earthwork with un-manned remotely controlled excavator [1]. The IES system is comprised of two elements: (1) an excavator operating independently around the site, performing earthwork; and (2) an intelligent task planning system providing paths for the excavator and organizing optimal work order. The IES ultimately aims to automate the recognition of a work environment, create work order, and operate the excavator to carry out the work as an un-manned system (Fig. 1). The focus of this paper is on the recognition of work environment — normally, the very first task conducted with intelligent task planning. In order to recognize work environment, several methods are usually employed, the most representative of which would be surveying.

There are many previous researches on automated object recognition for construction field, especially 3D surface modeling using various sensors. Furthermore, the 3D modeling technology has become one of the most popularized survey methods used for construction environment in recent years [2,3]. For similar reasons, terrestrial 3D laser scanner[1] with high resolution and accuracy is recently gaining popularity, as a technology that enables 3D modeling of surrounding environment [4]. Although this type of laser scanner is associated with a number of factors that cause error [5], the scanner is capable of providing 3D surface model for a large construction area in relatively fast in time compared with total station, and it has sufficient durability that is suitable for construction sites [6]. 3D laser scanners are now being applied in a wide range of fields, including disaster prevention [7,8], automobile and health care industries, and cultural properties restoration. Recently, a number of changes and improvements have been made

* Corresponding author. Tel.: +82 31 910 0024.
E-mail address: chae@kict.re.kr (M.J. Chae).

[1] A type of 3D imaging system also referred to as LiDAR or LADAR.

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