A DEVELOPMENT OF 3D IMAGE DATA MERGING MODULE FOR INTELLIGENT EXCAVATION SYSTEM

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ABSTRACT This research is a part of Intelligent Excavation System (IES) Development Project which aims the autonomous excavator for earthwork. The developed module focuses on measuring real-time productivity for Task Planning System(TPS) of the IES. This module merges 3D data obtained using two different 3D imaging systems : The 3D laser scanner ; and the stereo vision system. Real-time productivity of IES is calculated automatically. Once point cloud data is acquired by the 3D scanner, it is converted into mesh surface. Some post processing such as mesh optimization (reduce slenderness) and noise filtering are performed. Point cloud data is also acquired by the stereo vision, which is installed on the top of the cabin of the IES. Teo different 3D surface data are merged by the automatic fitting and smoothing algorithm. Excavated earth volume changes are recognized during the merging process. This research evaluates the performance of the merging algorithm using the real data from the civil earthwork site.

Keywords: *IES(Intelligent Excavation System), 3D Image System, Civil Earthwork, Construction Automation, Data Merging Algorithm*

1. INTRODUCTION

The excavation on a construction site, a basic operation for all earthworks, levels topography to an intended purpose in order to construct building. For the automated excavation, the major work of excavator which is being used most extensively now, various studies have been conducted throughout the world, but because of the problems with regard to the work process on the variable environment, a non-fixed topography, most of studies resulted in not full-automation but semi-automation.

This Study, therefore, purposed to build a basic technology for developing an efficient IES to actively respond to the variable construction environment through developing the 3D image data merging module using the LiDAR system, a technology to overcome any limits which the existing studies have.

2. Scope and Methodology

This Study intended to develop a module to automatically merge the earthwork data acquired from two kinds of 3D units for managing the real-time productivity of IES, a part of IES research for developing the autonomous excavation system.

The module, which was developed for planning and measuring the real-time work status of a task planning system (TPS) of IES, acquires 3D image data using the two kinds of units, 3D laser scanner called LiDAR and a stereo vision, combines in real-time the acquired data on TPS, grasps the automatically progressed excavation status, and then makes TPS measure the change or progress of operation path through the above process.

So, this Study limits the research scope to developing the 3D image merging module which makes TPS grasp the real-time work progress through merging efficiently the 3D image data acquired from the two different units.

3. Acquisition of 3D Image and Data Merging

The acquisition of 3D image can be accomplished through acquiring the topography data for an excavator to be operated using a vehicle equipped with a broadband laser scanner as the following Figure 1 and the image regarding the real-time work of excavator can be acquired using the stereo vision mounted at the excavator.

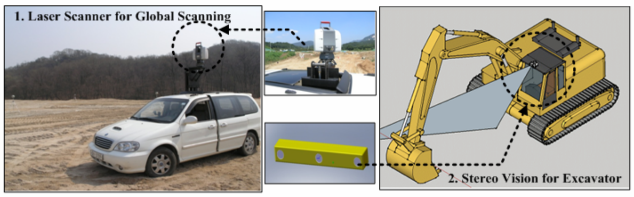

Figure 1. 3D Image Acquisition H/Ws

The two units acquire the topography data in the form of point cloud each other and then the acquired data are merged into one through a processing module called a World Model Controller (WMC). The 3D image-processing module developed in this Study is composed of a portable LiDAR system for acquiring the topography data regarding work targets, the stereo vision for acquiring the task data of excavator, WMC for managing the data acquired from the two units, and a communication module for transmitting the data between WMC and each Hardware.

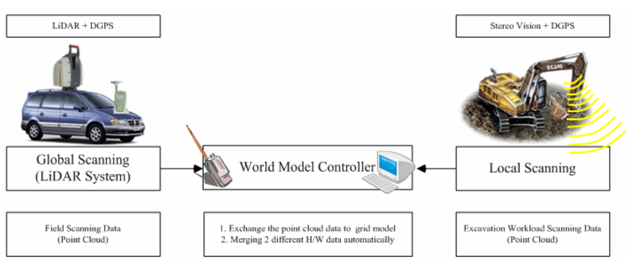

Figure 2. 3D Image Data Module

The data acquired from the stereo vision mounted on excavator are defined as local data (Yoo H, 2009) and the work topography on the front of excavator is shot at each excavation. Then, the local data are transmitted to EMC DB through wireless network merging Differential Global Positioning System(DGPS) coordinates of IES under operation and detailed excavation data into the point cloud data of stereo vision.

The data acquired from each unit as such are automatically merged using ICP algorithm at WMC (Jung S, 2010).

4. Data Processing of Module for TPS of IES

The 3D image-processing module developed in this Study has a data-processing process as the following Figure 3.

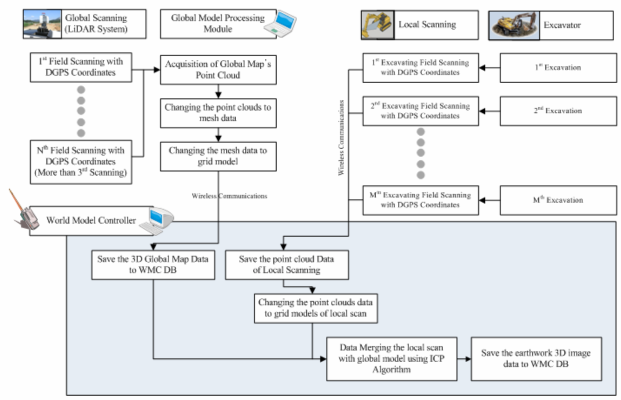

Figure 3. Data Processing of 3D image acquisition

As shown as the above Figure 3, after the global scanning point cloud measured at three locations or more is loaded, the signal of global scanning completion is sent to WMC at LiDAR system, then WMC generates automatically the global model with point cloud data. The generated point cloud global model is converted to mesh data again, and finally is converted to grid data. After the completion of grid data global model, WMC transmits it to TPS again and the optimal path for automatic operation of IES is generated based on the global data (Chae M, 2009). After the operation path of IES generated at TPS is transmitted, IES starts excavation, the operation results of excavator are shot by the stereo vision each time by the number of times of excavation, the point cloud data, in addition to the detailed information on excavator and DGPS on operation location, are delivered to WMC through wireless network, WMC calculates the corresponding point cloud data, DGPS data and detailed information data with grid data, and the operation results on the corresponding location are merged into the grid data global model saved at the pre-generated DB. When one time of the task is finished, WMC calculates excavating volume reduced by local data and then estimates the excavating volume per one time of excavation of IES.

This Study conducted the field test over five times for validating and complementing the developed module performance and the following Figure 5 shows a field test example.

As a result of multi-field tests, the module developed in this Study made sure that the function to merge the data acquired from two different 3D image H/Ws and to compare their volume are performed smoothly.

5. Conclusions

The performance results are as follows:

1. The 3D image-merging module is composed of WMC module to deal with the two Hardwares, laser scanner and stereo vision, and a communication module for data communication between LiDAR system and WMC.
2. The developed WMC can confirm the real-time excavating volume through merging automatically the data acquired from the two H/Ws and comparing the one-time volume of excavation.
3. The field test was conducted for confirming the performance of developed module and, as the result of test, the developed module showed the performance possible to field application.

The developed module in this study will be attached to IES in future and thereafter the field test is scheduled to be conducted for the directly, entirely automatic unmanned excavation, so the results are likely to contribute to the basic technology for the automation of medium – and large - sized equipment on site.

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