TASK PLANNER FOR AUTONOMOUS EXCAVATOR CONSIDERING WORK ENVIRONMENT

Jeonghwan Kim and Jongwon Seo*

Department of Civil and environmental Engineering, Hanyang University, Seoul, Korea
** Corresponding author (jseo@hanyang.ac.kr)*

ABSTRACT: The earthwork is essential procedure for all construction projects. Because of its importance in terms of cost and time, it should be managed effectively. In light of this, an automated excavation system is being developed by a research consortium formed in Korea to improve productivity, quality, and safety of the conventional earthwork. This paper presents the excavation task planner for autonomous excavator which was devised to incorporate the intelligence of the construction planner and the skilled operator into the robotic control mechanism of the automated excavation system. The structure of the task planner has been designed in harmony with the sensing and the control schemes of the automated excavation system. The algorithms for the excavator's path considering dump trunk and obstacles were developed.

***Keywords**: Excavator, Task Planning, Automation*

1. INTRODUCTION

The earthwork is essential procedure for all civil engineering projects. The excavator or backhoe, which is the mostly used for earthwork, still frequently operates in dangerous environment such as steep slopes and often causes serious problems in safety. Moreover, construction industry has still depended on the labor input through the use of the construction equipment because of unstructured and dynamically changing work environment. In light of this, the Intelligent Excavating System (IES) research consortium has established to improve the productivity, quality and safety of current excavating and/or earthwork system by the Ministry of Land, Transportation and Maritime Affairs (MLTM) of Korea.

In IES research, the proper range of excavation (i.e. reach and depth) of a selected excavator should be considered during task planning, and the optimal platform locations and their orders for execution of excavation work need to be identified in order to give proper guidance to excavator. By reason of this, a task planner for autonomous excavator has been developed, and introduced [1-4]. In this paper, we address improvements in the task planner considering work environment.

2. TASK PLANNER FOR EXCAVATOR CONSIDERING WORK ENVIRONMENT

The task planner is the technology to create the working plans by granting the earthwork and the superintendent's knowledge to enable IES to perform the optimal earthwork plan on the basis of the virtual working environment in a computer identical to the practical working environment updated real-timely on the basis of the sensor data. As Seo and Lee discussed [1-3], developed task planner has several procedures to generate task plan. However, developed path planning algorithm in the task planner was only dealt with travel distance and the number of rotations of equipment.

According to our recent survey, however, the most critical factor in path planning was accessibility of dump truck. This constraint is a distinguishing factor from other common robot task planning algorithm, because excavator work as a team with truck, loader, bulldozer, and other construction equipment. Thus, in general type of earthwork, it is important to provide a task plan for autonomous excavator that dump trucks can have access to excavator constantly without any obstacles on their way. Based on the constraint that we examined, the function of task planner was improved using complete coverage path

planning model. Firstly, we divided the work area into two separated area ('A' and 'B') in order to provide for dump trucks to have more accessibility as shown in figure 1. 'A' area, closer to truck entrance, is to excavate for dump truck's workability and productivity, such as provide sufficient room for turning and waiting, etc. 'B' area is to excavate in zigzag pattern, which is simple and efficient work pattern.

Once cell division procedure was completed, the sequence of work cell is determined though a planning algorithm that chooses a highest accessibility of truck and moving cost.

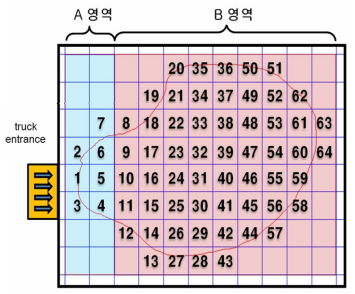

Fig. 1 Cell division using truck entrance and accessibility

After the cell division and sequence are determined, obstacles should be considered. There are many types of obstacles in construction site. Obstacles can categorized into 2 types; 1) Objects, 2) Terrain geometry. Objects are temporarily installed and operated facilities for construction (Crane, piles, materials), and terrain geometry is terrain's geometrical obstacles that construction robots cannot pass, like steep slope, excavated area. To cope with these obstacles, the path planner should generate detour ways to go to target. In this study, we developed an algorithm to find the lowest-cost path using excavator's velocity, rotation speed.

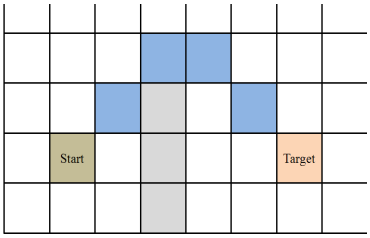

Fig. 2 Finding obstacle free path in autonomous excavator

As a Result of task planner, global position of autonomous excavator and its path and excavation point were generated and stored in server, then communicate with the control mechanism of IES with the devised plan for execution of work. As shown in figure 3, the excavator and task planner are interconnected into TCP/IP-SCI-CAN network, and the excavator work autonomously in accordance with task plan.

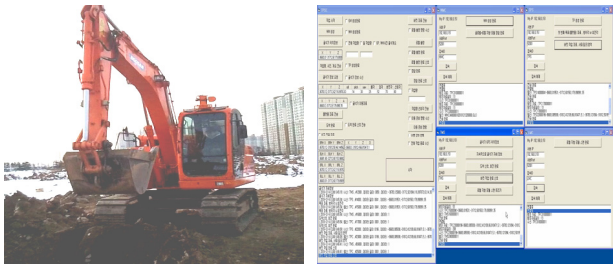

Fig. 3 Autonomous excavator and communicator for task planner

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