Cost Evaluation System for Plant Transportation Over Land

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***Abstract*— The purpose of this study is to develop a system for efficient cost calculation of transportation processes among many processes of plant construction. The developed system is called P-TAIS, and the transportation process can be analyzed by module and vehicle information through the system. The analysis includes in-path curve analysis, slope analysis, obstacle analysis, path width analysis, and vehicle analysis. The analysis then calculates the overall cost of the transportation process.**

Keywords-Modular plant; P-TAIS; Custom Path; Path assessment; SPMT; Cost optimize;

I. INTRODUCTION

As complex processes are required to build a plant [1],[5], careful decisions are required for the construction, and the estimation of the total cost before construction is very important [2].

There are two known methods to construct a plant [3]. The first method is stick-build, where materials are transported to the site, and then fabricated to become a part of the plant. The second method is modular method, where sections of a plant are pre-made and transported to the site to later be assembled. There exist pros and cons of each construction method, depending on the requirements of each plant. When both methods are feasible, however, the modular method is usually more advantageous in terms of construction period and cost [4].

This research focuses on the transportation of plant module on land. Compared to the stick build method, modules getting larger and heavier in modular plant for optimized cost, their transportation on land can act a constraint at the scale of entire plant project. Therefore, this research aims to provide a web service for cost assessment and integrated management on land transportation required for plant projects. This service is named Plant-Transportation Analysis Information System(P-TAIS) [6].

Section 2 introduces the structure of the P-TAIS system and the role of each page. Section 3 introduces the five analyzes used in the P-TAIS system. The brief method of each analysis and the factors for cost analysis are explained. Section 4 describes the cost analysis method using the factors obtained through the analysis. Finally, a short summary of the overall system and future work to improve the shortcomings of this system are presented.

II. THE P-TAIS SYSTEM

P-TAIS aims to simplify this process and replace it with a web-based analysis. It allows freedom of access to information for all the members participating in a plant construction project. All of the information on past projects can be managed in an organized way through P-TAIS, and for the current ones P-TAIS can be used for real-time sharing of information. The client only needs a web browser to use P-TAIS, and no data is stored on client.

A. P-TAIS Structure

The schematics of P-TAIS is shown in Figure 1. To reach the analysis page on the land transportation of a module, the user is asked to create/manage project and the modules that the project belong. A module can be transported through C*ustom Path*, which is entered by specifying waypoints in addition to the origin and destination. Furthermore, there is also a link to swept-path analysis in the analysis page.

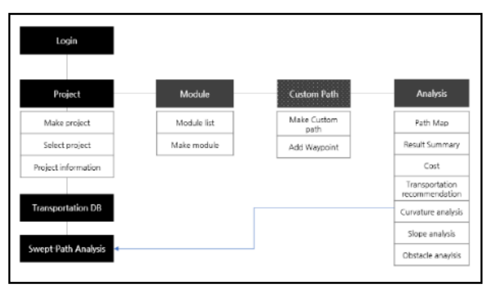

Figure 1. P-TAIS page structure

B. The Log-In Page

First, the company that is going to use P-TAIS is given username and password after an agreement. Whether P-TAIS will be a paid service has not been decided yet. If a client requests a computing power more than we currently own, we can negotiate over the cost of setting up additional computing resources.

C. The Projects Page

To create a project, it requires for user to enter the name of the project and the area in which the land transportation will be carried on. Once the project area is set, the area will be used to display all the maps in the context of that project. The projects are sorted by the time of the last use, and the number of registered modules is noted.

D. The Modules Page

Each project needs the modules to be registered. On module creation, user assigns a number to the new module, defines the origin and destination, the weight, and the size of a module. Each module. At the moment when the origin and destination are both set, route(s), multiple if possible, are created by Google Maps API.

E. The Custom Path Page

In addition to the route generated on the module registration, users can create more routes by adding up to 8 waypoints. This functionality can be used, for instance, to satisfy the requirement of passing through a gas station.

F. The Trasporters Page

Users can register means of transport that are available for the company. The types of those can be either of flatbed truck or of Self-Propelled Modular Transporter (SPMT). The list of the registered transporters is also available for viewing. The analysis page will later offer a recommendation on the best mode of transport among various configuration possible with the given transporters. Required information for each transporter are size, payload, Center of Gravity (CoG).

III. ANALYSIS

The analysis will result in a cost assessment for each of the route, based on the project, module, transporter information registered beforehand. The analysis will cover the following aspect of a particular route: curvature of the road, slope of the road, obstacles along the route, width of the road, transporter.

A. Curvature of the Road

First of all, Google Maps directions API provides the nodes consisting the route. Given this raw data, the curvature of the road is defined as the change in the direction of travel along the route at each node. The maximum of this value is calculated along the route. The analysis page contains a shortcut to start a swept-path analysis at this node of maximum curvature.

B. Slope of the Road

There is a limit to which SPMT can compensate for a slope of the road. Depending on the model, a SPMT can keep its payload level, on a surface sloped up to 6-7 degrees. Beyond this slope is where the payload is no longer secure. In this case, a further structural analysis should be carried out on the behavior of the module. The difference in elevation between the nodes divided by distance between the nodes, is equal to the slope of the road.

C. Obstacles along the Route

Obstacles on the route of a transportation can prevent the module from passing through. Obstacles along the route are detected automatically by object classification algorithm based on deep learning called YOLO v3 [7]. YOLOv3 is faster than other deep learning algorithms, reducing the time it takes to deal with classification of simple obstacles. Users have to upload a driving video along the route in analysis page, which is then processed to yield a result of type, position, height of the obstacles in the video.

D. Width of the Road

If the width of the road at a certain point along the route is wider than the width of the SPMT combination, either the road has to be widened or different route has to be considered. As mentioned above, the width of the road is an important factor, which can be analyzed using the Pix2Pix algorithm, which is widely used for satellite image analysis [8]. Pix2Pix deep learning algorithm processes satellite images to automatically count the number of pixels making up the road and it can be changed width of the road.

E. Transporter

SPMTs can move in a formation to carry a payload that is beyond the capabilities of individual SPMT. The analysis page contains the recommendation of the configuration of SPMTs, if more than one SPMTs are required.

IV. RESULT

Cost analysis is calculated for each module in the project. Figure 2 shows the overall structure of this. Total cost analysis can be largely calculated as the sum of three costs. The three costs are road maintenance costs, vehicle fuel costs and labor costs to run the project.

First, road maintenance costs can be calculated from data from the following analysis. The maximum rotation angle region obtained through the Curvature of the road analysis has a great influence on whether a vehicle carrying a real module can pass, which is a factor in calculating the road maintenance cost. This is because a module large enough to require many vehicles needs to widen the road for large turning angles. In addition, in the case of a slope data area of 6-7 degrees or more obtained from the slope of the road analysis, the slope repair of the road is required to move the module. Therefore, it acts as a factor of road maintenance cost calculation. In addition, depending on the number and type of obstacles present in the path, the actual vehicle must be removed in order to pass, which is another factor of the road maintenance cost. Lastly, if the road width is narrow, widening work is required, so the regional data obtained from road width analysis is also a factor of road maintenance cost.

Secondly, the fuel cost of the vehicle influences the calculation by the number of SPMT vehicles used to move the module obtained from the transporter analysis, the fuel cost and the total distance of the route the module is transported.

Finally, labor costs can be calculated from the number of project participants and the project duration. However, since it does not yet provide an input for elements of project headcount and project period input, it is not currently used as a cost analysis result.

V. CONCLUSION

The P-TAIS system introduced in this paper is a system used for land transportation of modular plants, providing management of each project and module, and recommending and analyzing the route for transporting modules. This allows project managers to assess the possibility of transportation projects through P-TAIS, and analyze the costs required before contracting the plant project to ensure that the correct plant orders are achieved.

The system is not yet perfect, so there are some things that need to be fixed. Especially in estimating costs, more analysis is needed. This needs to be closer to realistic cost calculation through much communication with the company. There is also a need to expand and update the analyzes to further refine these factors.

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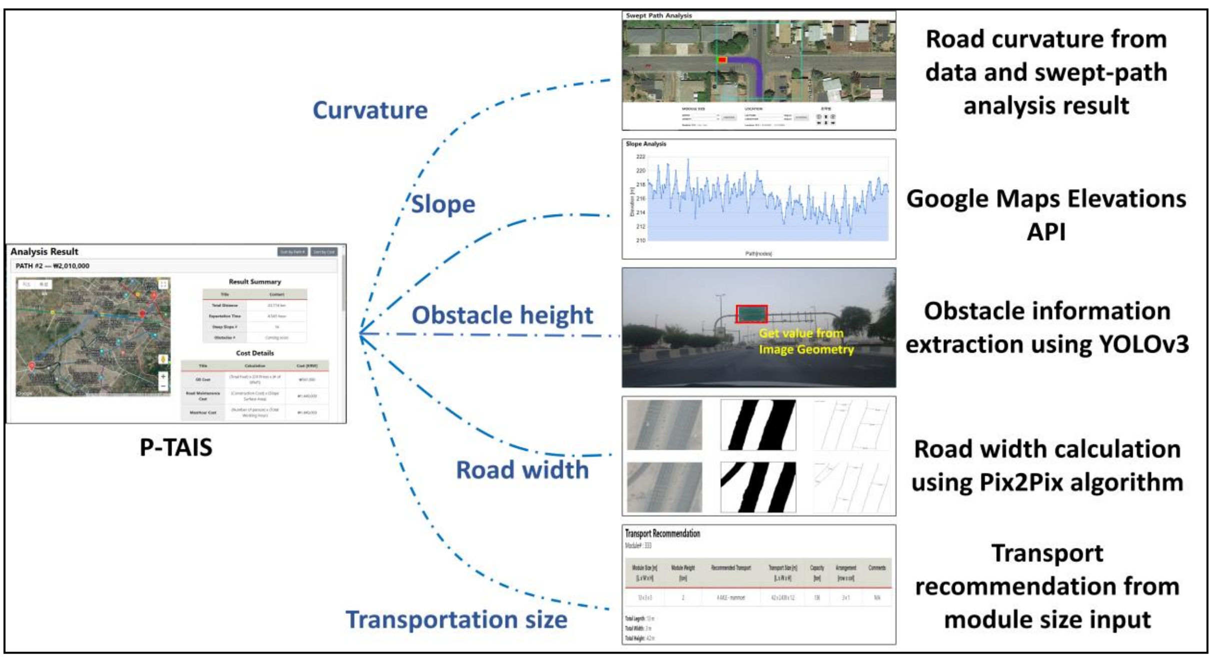

Figure 2. P-TAIS Cost Analysis Structure