Dynamic Simulation of Underwater Construction Robot Vehicle for Cyber Physical Operating System

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ABSTRACT

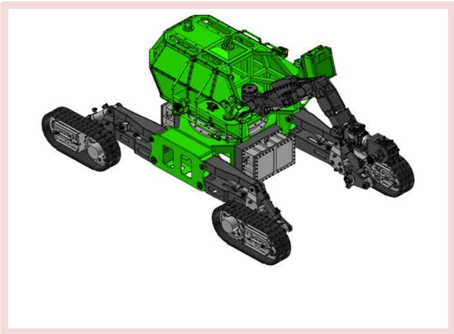
To overcome the difficulties of remote operation, smart operation of the marine robot using cyber-physical operating system (CPOS) is introduced. A digital twin model of the underwater robot vehicle has been developed for the CPOS system. The driving simulation of the underwater robot vehicle is carried out under 0.5m/s. The vertical motion and longitudinal motion on different road conditions are analyzed, respectively. The dynamic behavior of the underwater robot vehicle under different driving conditions is also analyzed to investigate the performance of the developed digital twin model.

1 INTRODUCTION

Remote operations of underwater robots are difficult due to the limited sonar and vision sensor information. To overcome the difficulties of remote operation, smart operation of the marine robot using CPOS is introduced. Han et al [1] developed the digital twin model CPOS system. In the paper, the method for establishing the digital twin model for the underwater robot vehicle is explained. The equations of motion are generated by using the recursive subsystem synthesis method with parallel processing [2]. To establish the underwater robot vehicle, driver reaction force model, rotational spring damper element for representing the non-linear leaf spring, and track element are developed. In this paper, the recursive subsystem model and track element are explained and several simulations are carried out.

2 DYNAMIC MODELING OF UNDERWATER ROBOT VEHICLE

The underwater robot vehicle model has 49 bodies, 62 joints, and 30 degrees of freedom as shown in Fig.1. The track model with a rubber track is composed of a sprocket, a roller, and rubber track links. For the remote operation of the digital twin model, real-time analysis is important. Thus, it is required to generate efficient track modeling. As for the efficient track model shown in Fig.2, multiple contact points are used for calculating the contact forces between track links and ground. The friction forces of the track are calculated by using the road friction coefficient, slip ratio, and vehicle velocity. The road friction coefficient is determined by using the comparison with tests. A typical test device for obtaining the friction characteristics between road and track is designed and several tests are accomplished.



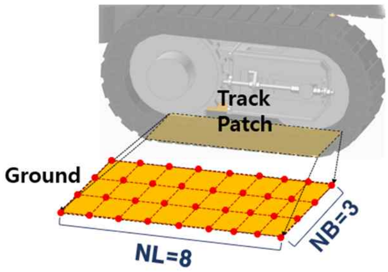


Figure 1. Real-time underwater robot model. **Figure 2**. Contact point for track force model.

3 DYNAMIC SIMULATION

The driving simulation of the underwater robot is carried out under 0.5m/s as shown in Fig.3. The bottom road shape [3] is used for the computer simulation. The vertical motion and longitudinal motion on different road conditions are analyzed, respectively.

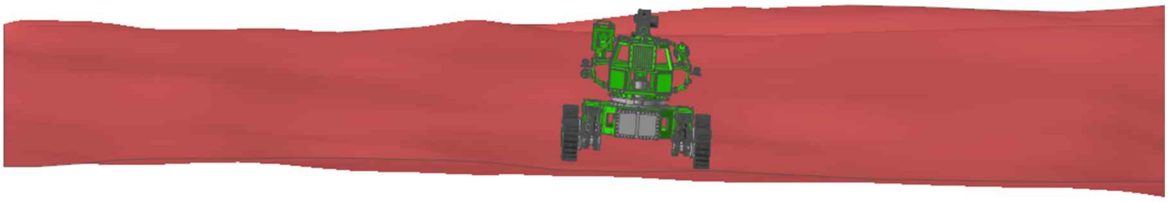


Figure 3. Driving simulation of the underwater robot on the irregular road.

4 CONCLUSIONS

In this study, a dynamic model for underwater robot vehicle with tracks is established for CPOS. A real-time track model is developed and the road for underwater condition is made. The dynamic behavior of the underwater robot vehicle on different driving conditions is analyzed.

Acknowledgments

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