Validation of the Velocity Planning Method for the Off-road Unmanned Ground Vehicle

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The optimal velocity planning is important for the off-road UGV (Unmanned Ground Vehicle) to maneuver as fast as possible while maintaining vehicle stability. Based on the local path information and the LiDAR information which provides terrain roughness in front of the UGV, the optimal permissible velocity must be determined in real-time. Different from the previous look-up table based methods [1, 2], an optimal permissible velocity planning method has been recently developed based on the RTT (Real-Time Traversibility) analysis [3]. The basic concept is depicted in Fig. 1. The RTT analysis is comprised of the parallel predictive simulations of a multibody UGV dynamics and control model. In the RTT analysis, the UGV predictive simulations are carried out with seven different velocity candidates in parallel, using a workstation with an Octo-core CPU. In each UGV parallel simulation, the UGV model is used to drive about 16 meters ahead along the given trajectory with a constant candidate velocity. The path-tracking controller is utilized with the preview distance concept to follow the given trajectory and velocity. In every waypoint on the given trajectory, four stability indices, which consist of roll stability, pitch stability, lateral stability and vertical stability, are evaluated. Based on these evaluations of the stability indices on each way point from different parallel simulations, the optimal permissible velocity command for the given trajectory is determined.

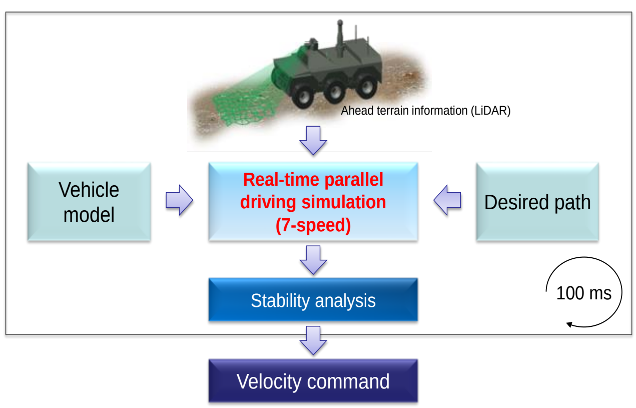

Fig. 1: Optimal velocity planning using RTT analysis

In this paper, in order to validate the proposed optimal velocity planning method experimentally, the actual field tests of a prototype UGV has been discussed. The RTT module which includes the proposed velocity planning method has been installed to the prototype UGV. For the first experiment, bump run maneuver has been carried out in the continuous sine bump course as shown in Fig. 2. The left-hand side figure of Fig. 3 shows the velocity response of the prototype UGV with the limited velocity of 10 km/h (2.77m/s). In the flat road, the velocity of the UGV increased up to the limited velocity (2.77 m/s) and then remained constant. About 2 m before the bump, the velocity started to decrease. The corresponding velocity command at the location A is also shown in the righthand side of the Fig. 3. This shows that the prototype UGV properly followed the velocity command from RTT module and the proposed velocity planning method was working appropriately. In the future, the simulation and experimental results will be compared after the through experimental data analysis.

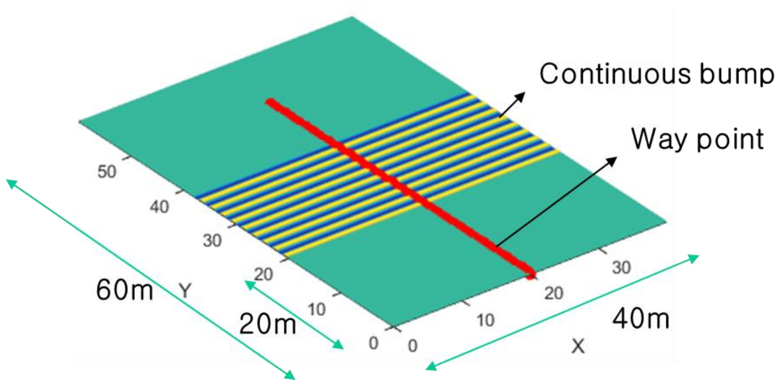

Fig. 2: Bump test course for the UGV with RTT analysis module

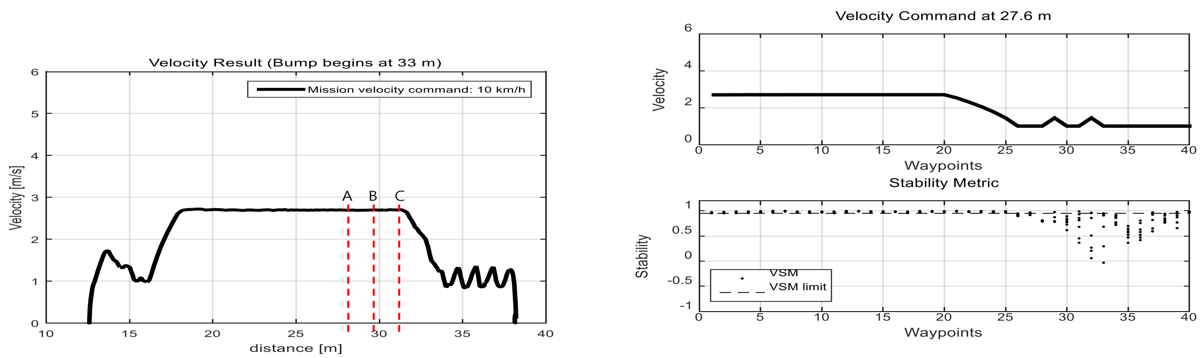

Fig. 3: UGV velocity responses for continuous pump run with the limited velocity of 10 km/h

Acknowledgements

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