HIVE 3.0: Autonomous Follower for Culvert Inspection

Brandon Gamble, Dryver Huston, Tian Xia
College of Engineering and Mathematical Sciences, University of Vermont

Introduction

Culvert failures can cost upwards of $10 million to fix. The Vermont Agency of Transportation (VTrans) inspects nearly 10,000 small culverts annually. Inspection is critical for assessing preventative maintenance. This is the start of a new project to research and develop next generation Hydraulic Inspection Vehicle Explorers (HIVEs). The HIVE 3.0 is designed as a modular sensing apparatus that can be scaled to fully autonomous culvert inspection, making culvert inspection efficient, effective, and low-cost.

Figure 1. Left: HIVE tank. Right: Culvert with sediment buildup.

System Design

Culvert inspection currently involves driving a remote-controlled vehicle through the culvert while streaming a video to the operator. The "Crawler" currently available is too costly for ubiquitous use. HIVE 2.0 was only able to operate in direct line of sight. HIVE 3.0 uses LIDAR to autonomously follow a leader HIVE. Carrying a repeater antennae, the HIVE 3.0 will stop at a corner to bounce the signals of the leader HIVE, allowing it to continue around corners.

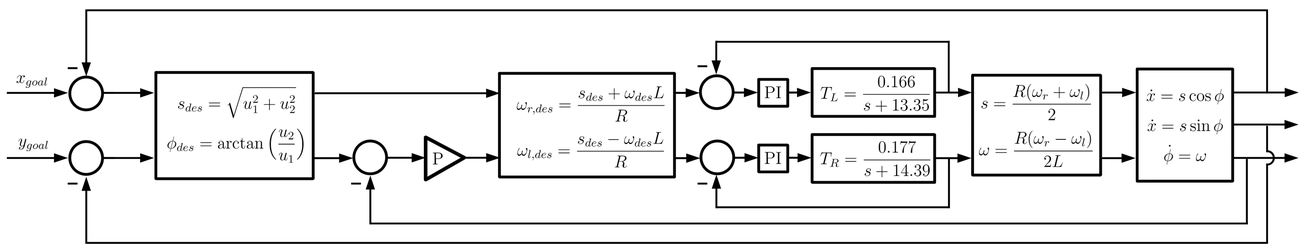
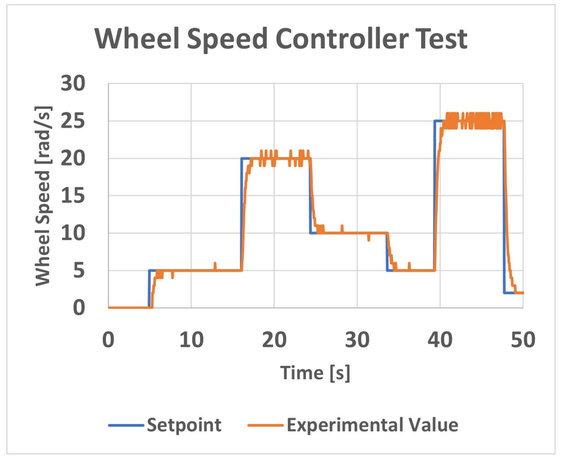


Figure 2. Block diagram of Go-To-Goal control algorithm.

Results

A simulation environment has been developed for testing various stages of the design. Following successful simulation, the control algorithm for motor speed tracking was verified experimentally. The full Go-To-Goal algorithm has been successfully simulated. The simulation environment will allow further development of obstacle avoidance before moving to full scale hardware tests.



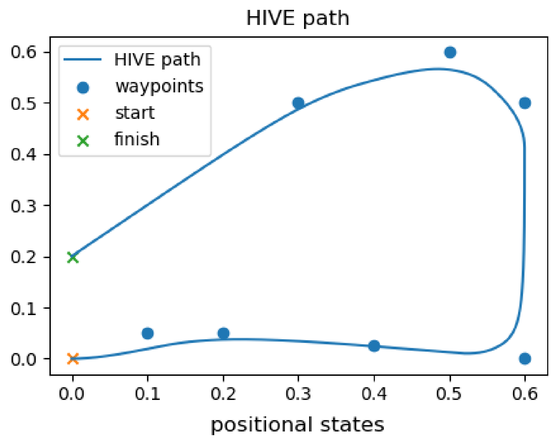


Figure 3. Left: Experimental motor speed tracking. Right: Simulated waypoint tracking.

Conclusions

This iteration of the HIVE family focuses on sensing and control, independent of vehicular body. It can be readily adapted to any RC vehicle. Its scalable design is a significant increment toward fully autonomous culvert inspection.

Acknowledgments

Michelle Redmond of VTrans provided technical guidance. This research is supported in part by NSF 2119485 and the Vermont Agency of Transportation, project 23-01.

References

Burton J, Orfeo DJ, Griswold L, Stanley SK, Redmond M, Xia T, Huston D. (2021) "Culvert Inspection Vehicle with Improved Telemetry Range" Transportation Research Record, doi:10.1177/03611981211021850 published online July 27, 2021