HIVE 3.0: Enhanced Culvert Inspection

Brandon Gamble, Evan Trombley, Krisha Reddy, Dryver Huston, Tian Xia
College of Engineering and Mathematical Sciences, University of Vermont

Summary

The Vermont Agency of Transportation (VTrans) is responsible for the inspection of 10,000 small culverts annually to help prevent failures, which can cost millions of dollars.

The Hydraulic Inspection Vehicle Explorer (HIVE) 3.0 is a modular sensing and control package designed for enhanced human-controlled inspection with scalability to fully autonomous inspection.

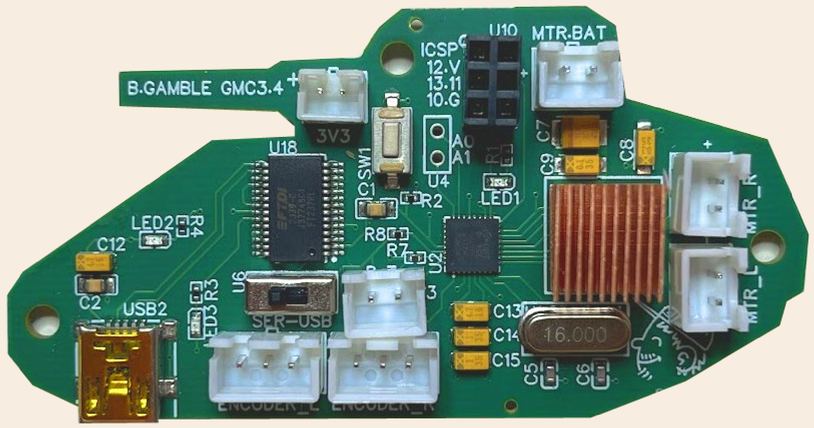


Figure 1. Motor Control Board

Methodology

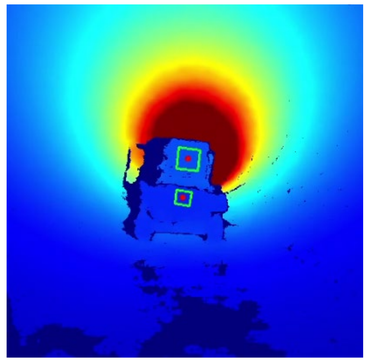
The HIVE 3.0 uses a RealSense depth camera for detecting obstacles as well as an RGB camera to detect other HIVEs. A simple P-PI nested loop controller design is used for navigation. The HIVE controller module is easily tuned to any differential drive robot.

Results

Using an autonomous follower as a relay point in a mesh network to transmitting video and control signals allows for deeper culvert access than previously achieved.

Passing the RGB camera feed through a machine learning algorithm allows for crack detection along the inside surface of the culvert.

It is also possible to use the depth images of the RealSense camera to create a map of the culvert.



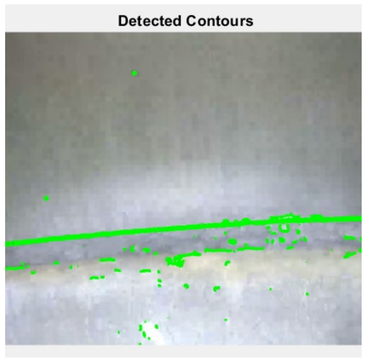


Figure 2. Culvert inspection test.
Top: Leader and follower entering culvert.
Bottom left: Follower POV, depth and leader detection.
Bottom right: Crack detection.

Conclusions

The HIVE 3.0 enables culvert inspection beyond simple visual inspection, such as crack detection and mapping.

The system is designed on a platform intended for scalability, including fully autonomous swarm inspection.

Figure 3. HIVE 3.0 Prototype

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