Developing a Robust Robotic Inspection System for Internal Inspections of Small Culverts

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Eleanor Rightley[1], Wesley Cook[2], Claudia Mara D. Wilson[2], Curtis O'Malley[1], Isabel Morris[2]

[1]Department of Mechanical Engineering, New Mexico Institute of Mining & Technology, Socorro, NM 87801

[2]Department of Civil and Environmental Engineering, New Mexico Institute of Mining & Technology, Socorro, NM 87801

Figure 1. An internal view of an NM-based corrugated steel culvert with a moderate amount of silting and corrosion. Image was obtained via the inspection system.

Abstract & Background

A non-proprietary inspection system utilizing a wheeled robot has been developed for use in the internal inspections of small culverts down to a 61 cm (24 in.) diameter, with recorded inspection videos providing additional data to assist the New Mexico Department of Transportation (NMDOT) in asset management. Culvert inspection data is vital to maintaining the functionality of the roadways in New Mexico and internal inspections allow for a comprehensive understanding of the condition, or "health," of a culvert. The developed system has been field tested for inspections with live and recorded video feed up to 30 m (97 ft) into a 61 cm (24 in.) diameter circular culvert. Since this field testing was conducted, further work has been carried out to improve the strength and stability of the system.

Figure 2. An image of the internal inspection system at the outlet of an 24" diameter HDPE culvert.

System Highlights

The wheeled robot is outfitted with two separate first-person-view (FPV) video systems, which are used for robot and inspection camera movement, and are controlled separately by two inspection personnel. The system provides the synchronization of power supplies for the functions of movement, wireless transmission of live video, and system retrieval. Storage of all the inspection video data for each internally inspected culvert allows for further data analysis and post-processing of the collected data in the future. With the alignment of the required power sources, alongside an optimization of the sturdy video transmission system, a comprehensive system has been developed.

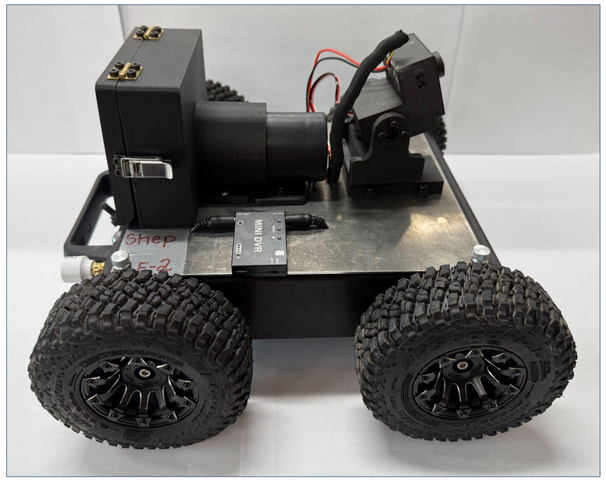

Figure 3. A right-side view of the wheeled robot, featuring the DVR module, directional camera mount, and battery mount & compartment.

Wheeled Robot Features

- Completely modular design for easy repairs and maintenance.
- Only two batteries are located on the wheeled robot itself:
  - 12 V, 6.0 Ah drill battery
  - DVR Internal Battery (3.7 V, 400 mAh lithium-ion battery)
    - Rechargeable via DC 5 V micro USB connection
- Both batteries are easily accessible, chargeable, and replaceable as is necessary in the field.
- Directional pan/tilt camera mount with a 12 V LED spotlight.
- Split inspection video and robot navigation controls and responsibilities.
  - Forward facing mounted camera allows navigation person to navigate the robot through culvert without interrupting inspection camera video to visualize obstacles.

Control Station Components

- Protected and carried in a medium visibility backpacking carrier pack.
- Two 2.4 GHz remote controller transmitters.
- Two 5.8 GHz video receiver monitors.
- Two remote controller to video monitor adapters.
- Surveyor's rope and reel.
  - Attaches to robot via a locking carabiner.

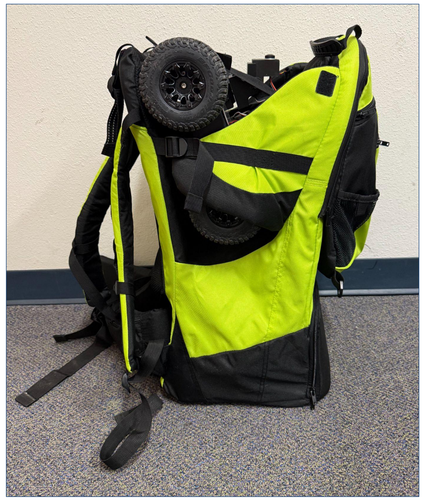

Figure 4. A right-side view of the carrier pack, which contains the wheeled-robot and all control station components.

Supply Kit Components

- Stored and carried in a standard size toolbox.
- Spare remote control transmitter batteries and battery charger.
- Spare robot drill battery and battery charger.
- 10,000 mAh portable power bank.
- Various charging cables.
- 12 V car port power inverter.

Figure 5. An top-down-view of the supply kit and its components.

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Contact Information

Eleanor Rightley: eleanor.rightley@student.nmt.edu
Dr. Wes Cook: wes.cook@nmt.edu
Dr. Claudia Mara D. Wilson: claudia.wilson@nmt.edu
Dr. Curtis O'Malley: curtis.omalley@nmt.edu
Dr. Isabel Morris: isabel.morris@nmt.edu