Autonomous Pavement Inspection Vehicle

BOISE STATE UNIVERSITY

Maruf Ahmed, Dr. Yang Lu*

Undergraduate Researcher, Principal Investigator*

Department of Computer Science, Department of Civil Engineering*

I. Introduction

Pavement condition and behavior are important factors in transportation for many reasons such as structural design of pavement, traffic, materials, subgrades and structural safety. But due to the complexity and cost of traditional inspection process, the pavement condition survey frequency is often incompetent to provide real – time data for advanced scientific observations. However, with the help of recent innovations in machine learning and image processing, it is possible to cut down costs significantly while maintaining good quality and frequency of pavement condition surveys.

Agency	Condition Data Collected	Frequency
Idaho DOT	Surface distress, rut depth, IRI	Annually
Florida DOT	Surface distress, faulting, rut depth, and IRI	Annually
Iowa DOT	Cracking, rut depth, faulting, Cracking, joints spalling, and IRI	Every 2 years
Colorado DOT	Cracking, rut depth, IRI	Annually
Oregon DOT	Surface distress, rut depth, IRI	Annually
Washington DOT	Surface distress, faulting, rut depth, and IRI	Annually
Virginia DOT	Surface distress, rut depth, IRI	Annually

Table 1: Condition survey data collection and frequency [1]

Shortcomings of traditional method:

- Relies on old technology for measurements
- Requires manual labor
- Prone to error
- Time Consuming
- Expensive

Benefits of proposed method:

- Uses machine learning algorithms for detection which increases prediction accuracy up to 30% [2]
- Very cheap (less than $1000 for each fabrication)
- Real time data collection and

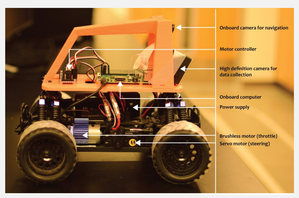


Figure 1: First revision

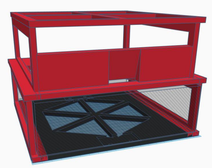


Figure 2: Platform model for Second revision

II. Workflow

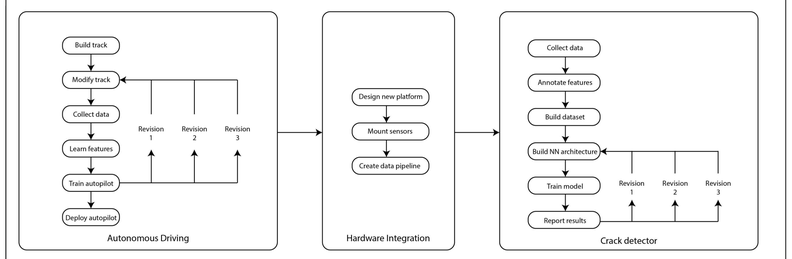


Figure 3: Workflow Integration

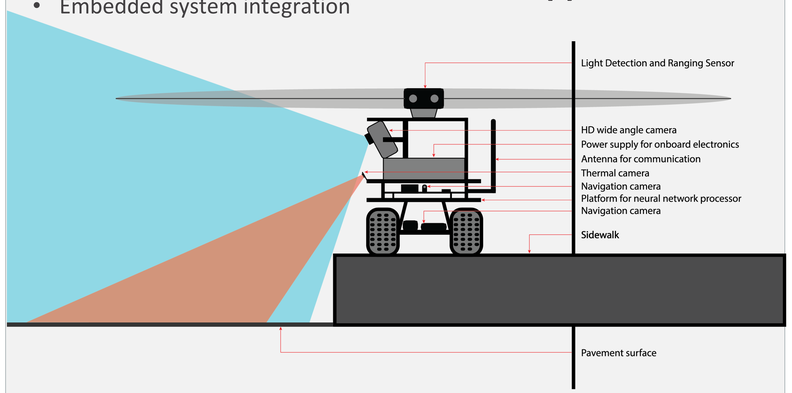
III. Methods

Autonomous Navigation

- Open source platform – Donkey [3]
- Allows further improvement and modification
- Scalable and easy to add new parts
- Embedded system integration

Image Recognition

- Open source neural network framework- darknet [4]
- Real time object detection algorithm – YOLOV3
- 4x-6x faster than other detectors. [5]

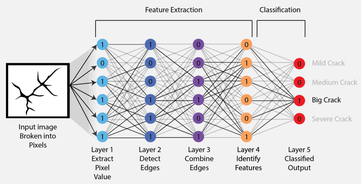


Autonomous Pavement Inspection Vehicle Platform

III. Results

We set up a test track and dummy cracks as a proof of concept. We trained both navigation and detection systems with properly labeled data. The navigation system is trained with 12,386 labeled images and the detection system is trained with 150 labeled images.

Figure 4: Detector Input



Structure of a Deep Neural Network

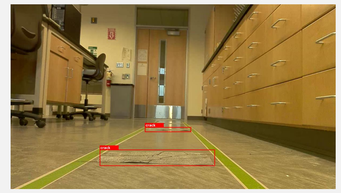


Figure 5: Detector Output

IV. Future works

Figure 6: Measurement Module

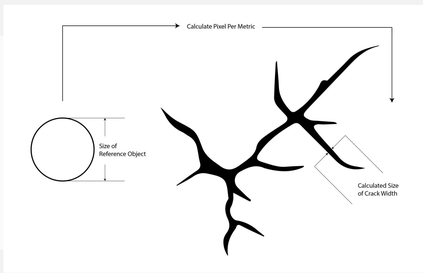


Figure 7: Measurement from reference

- Automated measurement of cracks for further classification
- Thermal camera sensor to differentiate actual cracks from already repaired patches
- GPS module to capture GPS tagged data for map integration
- LiDAR sensor attachment for effective obstacle avoidance

Sources:

[1] U.S. Department of Transportation. 'Practical Guide for Quality Management of Pavement Condition Data Collection'. *Federal Highway Administration,* www.fhwa.dot.gov
[2] Lee, Peter, (2016). Microsoft Research. Personal Interview by Roger Parloff. *Website: http://fortune.com/ai-artificial-intelligence-deep-machine-learning/*
[3] Roscoe, Will. et al, (2017 - 2018). Donkey – High Level Self Driving Library. *Github repository: https://github.com/wroscoe/donkey.git*
[4] Redmon, Joseph, (2013 - 2016). Darknet: Open Source Neural Networks in C. *Website: http://pjreddie.com/darknet/*
[5] Redmon, Joseph & Farhadi, Ali (2018). YOLOv3: An Incremental Improvement. *Cornell University arXiv*

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