An Automated System for Rail Transit Infrastructure Inspection
University of Massachusetts Lowell

Executive Summary

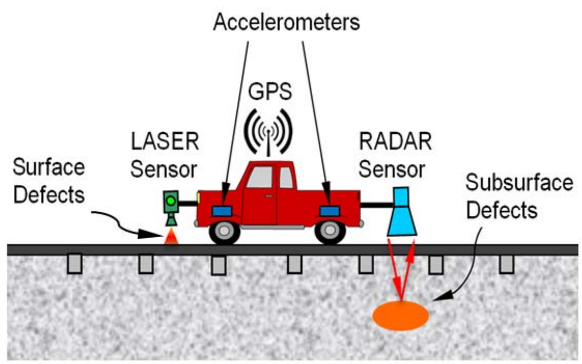
A critical aspect of the transit state of good repair is the inspection of rail transit infrastructure. The current rail transit inspections are primarily based on visual observation, which is time-consuming and labor-intensive. Also, they cannot effectively identify subsurface hazards. For instance, ultrasound is usually used for rail inspection twice a year, and an inspection vehicle is used to check the rail geometry every few months. For all other structures and facilities (e.g., ties and fastening systems), they are inspected manually on a weekly or monthly basis, which requires considerable time and efforts. This practice is typical for most transit agencies in the United States.

This project developed an integrated system to automatically collect and georeference surface and/or subsurface data for rail, concrete ties, fastening systems, and ballast. It consisted of Ground Penetrating Radar (GPR), 3D laser, Geographic Information Systems (GIS), encoder, accelerometer, and Global Positioning System (GPS).

Advanced algorithms and software tools were developed to interpret the data and to identify rail infrastructure surface and subsurface defects and safety hazards, such as broken ties (e.g., cracks in ties), missing fasteners, fouled ballast, and wide rail gauge. Also, a WebGIS-based decision support system with user-friendly interface was developed to help rail transit employees with no GPR and laser background utilize the data.

Rail transit agencies in the U.S. rely heavily on visual observation for track inspections. This manual method is time-consuming, costly, and unsafe and cannot effectively identify subsurface safety hazards. With the aging rail infrastructure, this proposed system is expected to substantially benefit the rail transit industry by improving track inspection efficiency, accuracy, and the safety of both the rail transit systems and track workers.

Findings & Outputs



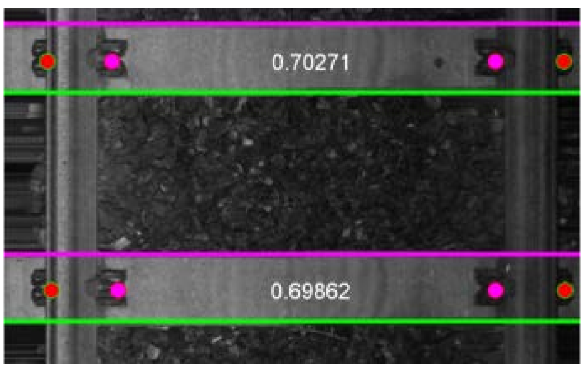
Each major component (e.g., GPR, laser, GPS, and accelerometer) of the system was developed/tested first in the lab to ensure that they worked properly. For testing the performance of the GPR subsystem, a wooden box was constructed in the lab and filled with soil, sand, and clean and fouled ballast. The results suggested that the developed GPR subsystem was able to accurately identify the locations of fouled ballast and subsurface pipelines. The team also conducted lab tests to evaluate the accuracy of the laser subsystem and found that its horizontal accuracy was less than 0.3 mm and its vertical accuracy was less than 0.5 mm.

The integrated system was then used to collect surface and surface data from Metro St. Louis and the Massachusetts Bay Transportation Authority (MBTA) during the summer of 2013. The system was designed to be easily mounted on a high-rail vehicle and performed reliably during the field tests.

Products & Outcomes

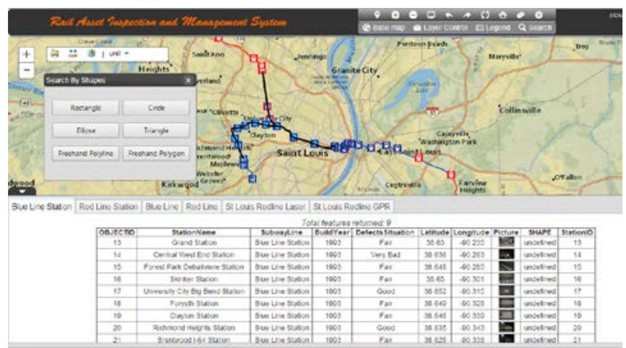
The research team also developed a set of algorithms and software tools to interpret the collected data, including

- A laser software tool for measuring rail gauge, identifying rail positions, cross-ties and fasteners, and detecting cracks in concrete cross-ties. A 3D template matching algorithm was developed for detecting missing fasteners;



- A GPR data analysis software package was developed that is capable of identifying and marking suspicious subsurface regions, including 1) a 2D entropy algorithm to automatically identify regions of interest; 2) a method for calculating the depths of subsurface anomalies, and 3) a graphic user interface (GUI) for the developed signal processing package;
- A track dynamic model for analyzing the collected accelerometer data. The team also developed a spectrum analysis model to identify hanging-ties based on the accelerometer data; and
- A WebGIS-based decision support system for managing, visualizing, and analyzing the collected and processed GPR, laser, and accelerometer data. A mobile App was also developed to facilitate data collection and field inspection trips.

Manuals and tutorials for the developed tools have been prepared. The research has generated three peer-reviewed conference publications and has been presented 5 times at international, national and regional conferences.



Post Project Initiatives

Based on the results of this project, a Laser Rail Inspection System (LRAIL) has been developed and successfully commercialized by Pavemetrics Inc., a member of the project team. In addition, some of the team members are exploring other innovative technologies for railroad infrastructure inspections, including drones, ultrasound, Digital Image Correlation (DIC), and infrared. The idea of using drones for railroad inspections has been funded by the USDOT CRS&SI program.

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