Intelligent Crack Sealing Planning using 3D Laser Technology

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Outline

- Research objective
- Research tasks
- Introduction to crack sealing
- Challenges of crack sealing outsourcing
- Estimation of crack sealing quantity using 3D laser data – a case study
- Brief review of performance study
- Conclusions and remaining work

Research Objective

- The objective of this research project is to develop a data-driven crack sealing planning tool for advancing the existing state-of-good-repair practices to achieve the highest return on investment for pavement preservation and to better utilize the existing infrastructure by prolonging its life. This tool is especially important because outsourcing has become a trend for crack sealing.

Research Tasks

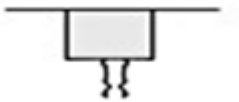
- Validate the crack map detection algorithms that can be applied to any type of sensing data, including 2D imaging and 3D line-laser-imaging data
- Develop a procedure to compute and estimate the cost of each crack sealing project using full-coverage, detailed crack characteristics data. This will help establish accurate crack sealing workload estimation and planning
- Develop a method to evaluate the effectiveness of pavement candidates selected at the network level by using the full-coverage, detailed level crack characteristics derived from detected crack maps so the return on investment of the crack sealing for each candidate can be determined or approximated

Functions of Crack Sealing

- Prevent water intrusion to underlying layer of pavement structures
- Reduce incompressibles, thus reducing crack growth and raveling

Methods

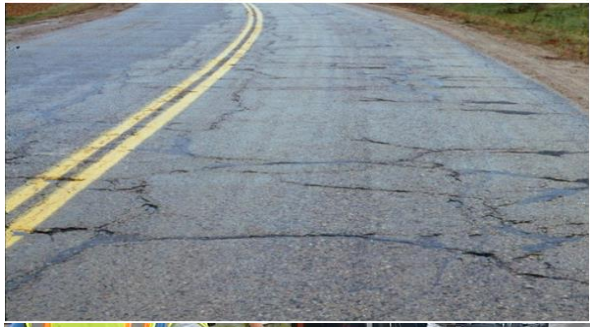
- Crack filling
  - Routine maintenance
  - Non-working cracks
- Crack sealing
  - Preventive maintenance
  - Working cracks (>6 mm yearly horizontal move)
  - Routing is normally needed



Pricing Issue with Crack Sealing

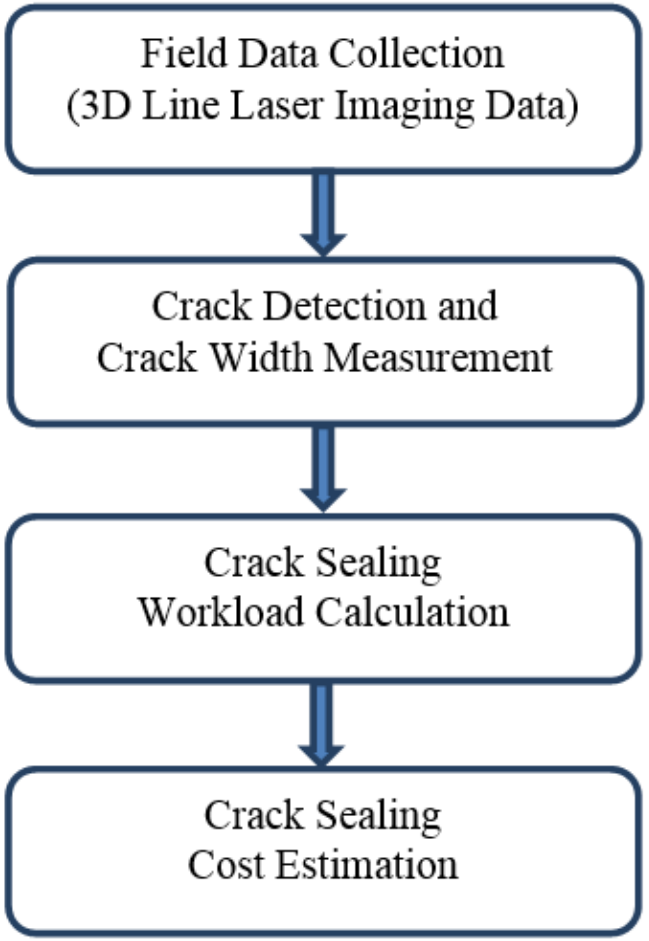
- By total gallon used
- By lane mile or unit area
- By crack linear foot

(Caltrans)

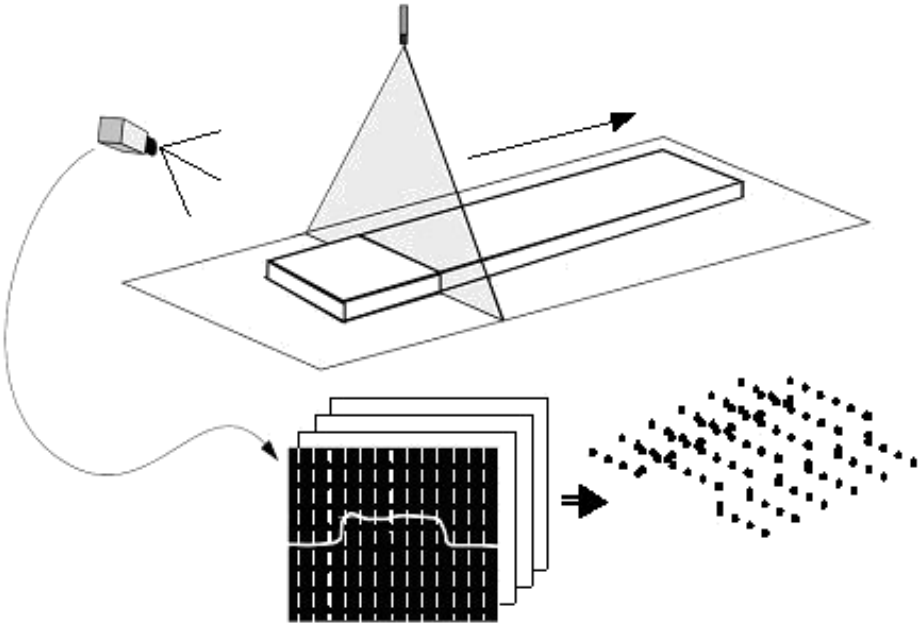


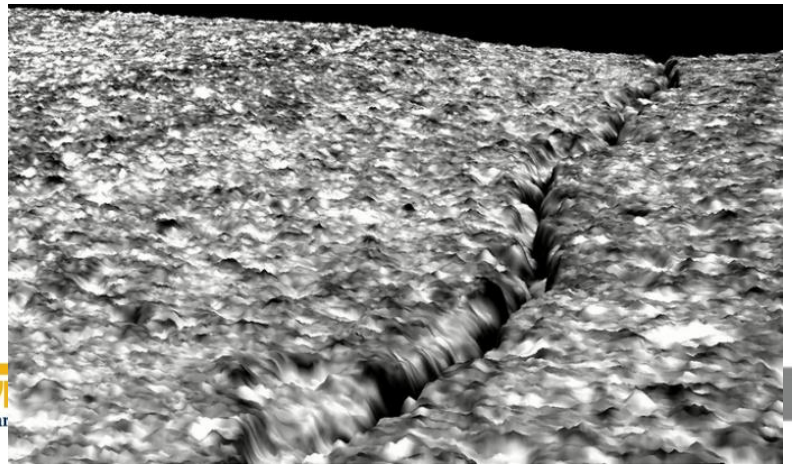
http://www.pavementinteractive.org

Automatic Crack Sealing Pricing



3D Line Laser Imaging Technology





1. Transverse direction : 1 mm

2. Elevation: 0.5 mm

3. Data points collected per second and width covered:

2 (lasers) * 2048 (points/profile/laser) * 5600 HZ = 22,937,600 points

2 (lasers) * 2048 (points/profile/laser) * 1 (mm) = 4.096 m

Georgia Tech Sensing Vehicle

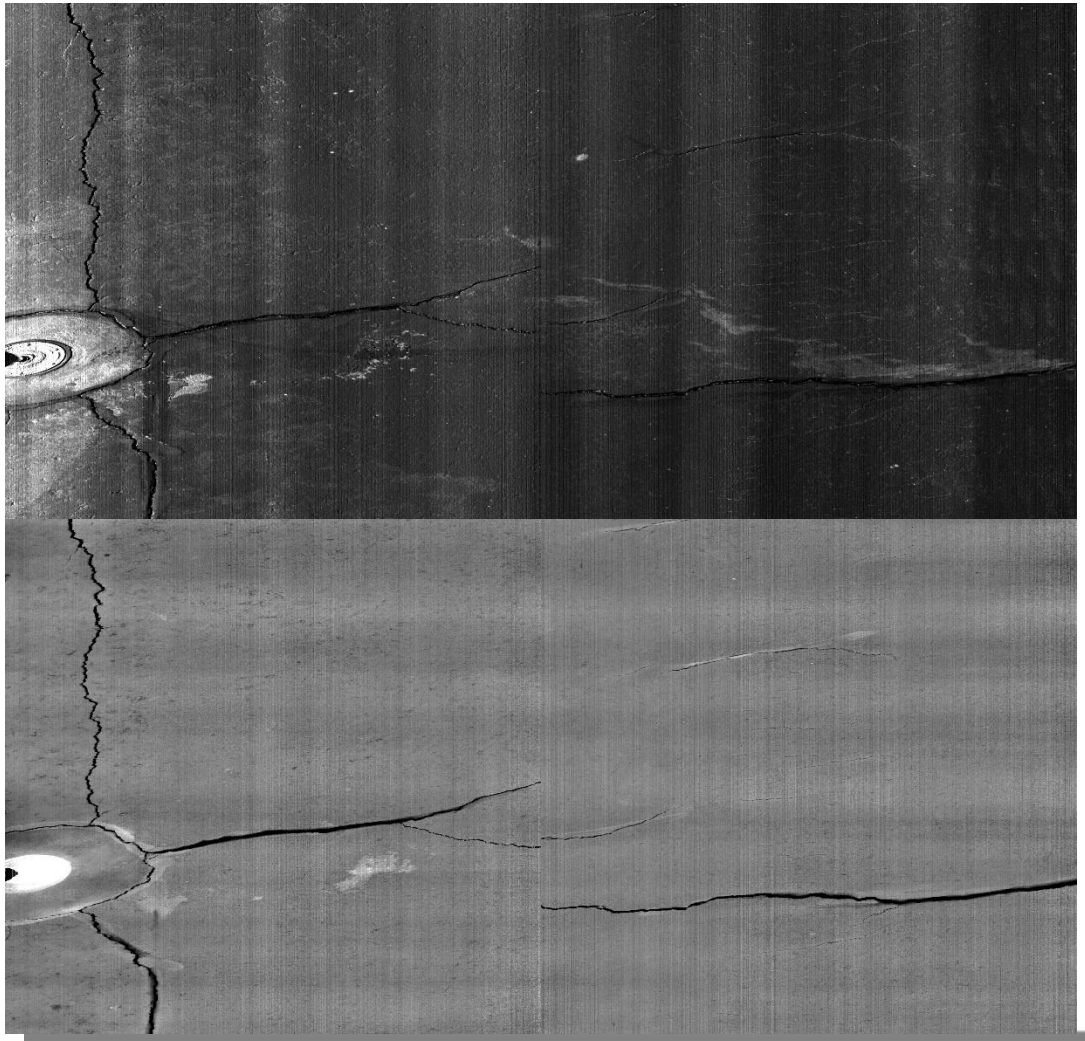
A Case Study with Atlanta Airport

Georgia Department of Transportation

Crack Sealing Criteria

Initial Crack Width	Depth for Routing
0 – 4.8 mm (0 – 3/16”)	No routing or sealing required
4.8 – 12.7 mm (3/16” – 1/2”)	25.4 mm (1”)
12.7 mm – 19.1 mm (1/2” – 3/4”)	38.1 mm (1-1/2”)
19.1 – 25.4 mm (3/4” – 1”)	50.8 mm (2”)
Greater than 25.4 mm (1”)	50.8 mm (2”)

3D Laser Data



Intensity Image (Illumination)

Range Image (Depth)

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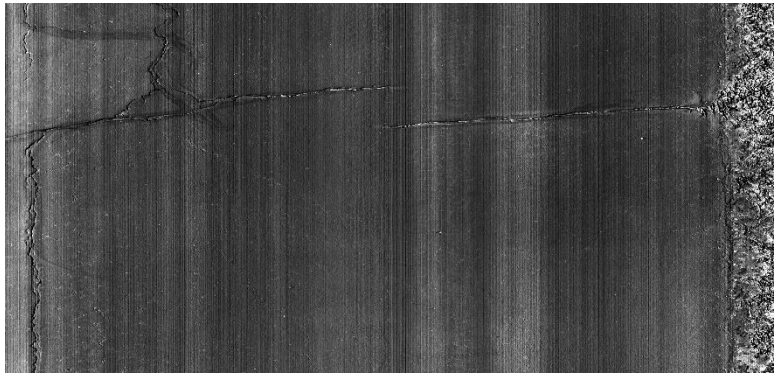
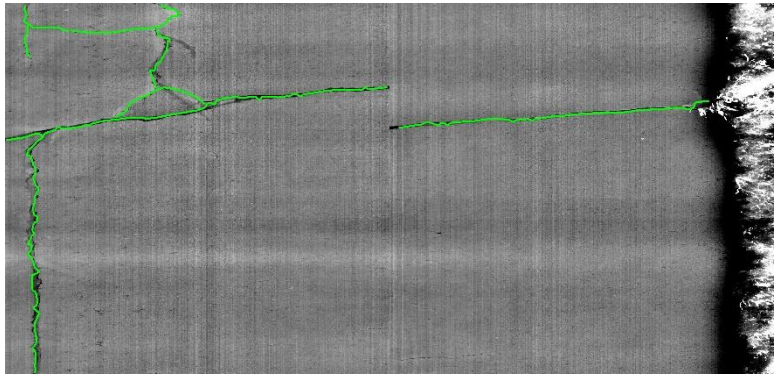
Crack Detection

Video Log Image

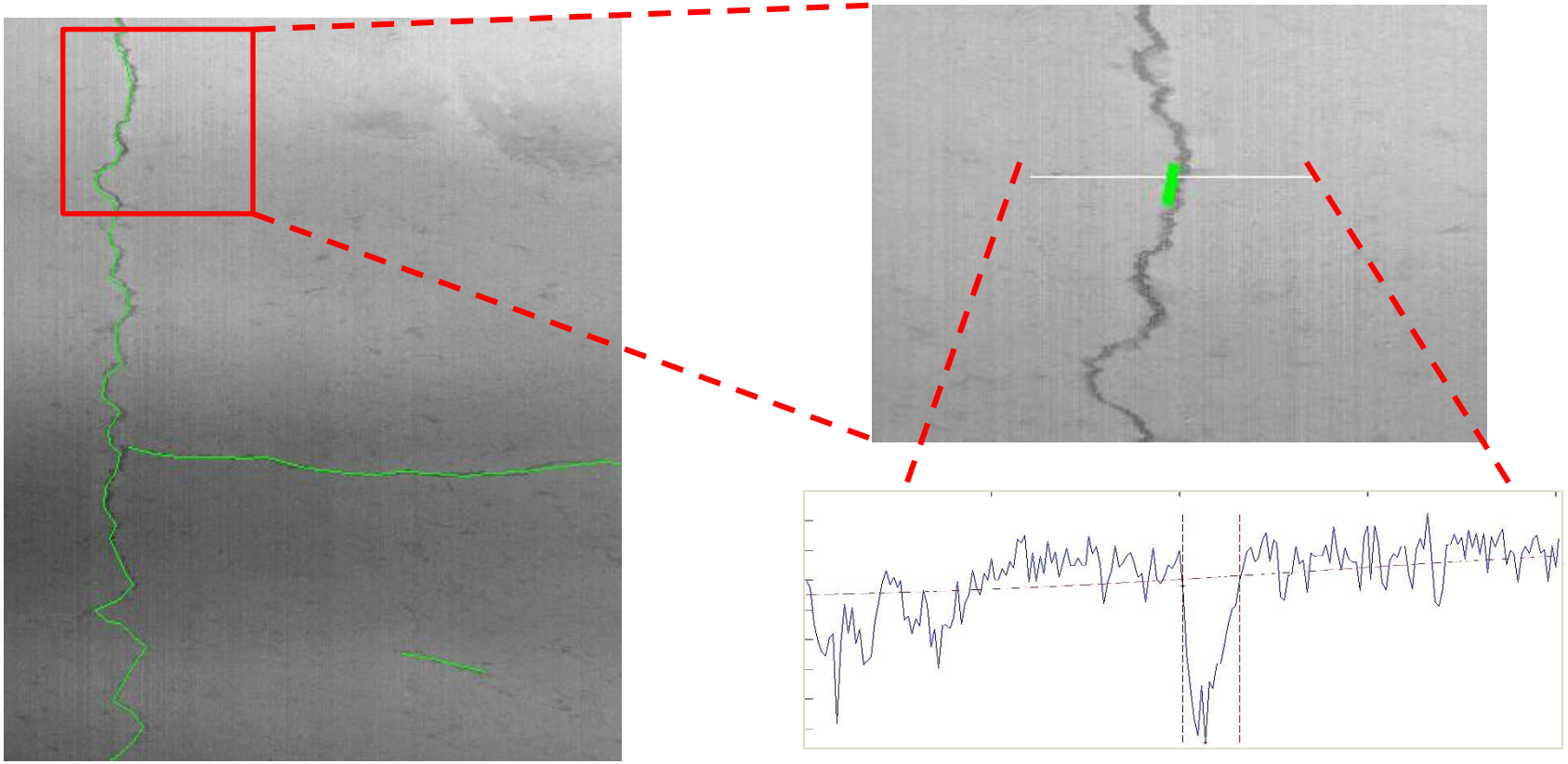


Intensity Image



Range Image with Crack Map

Crack Width Measurement

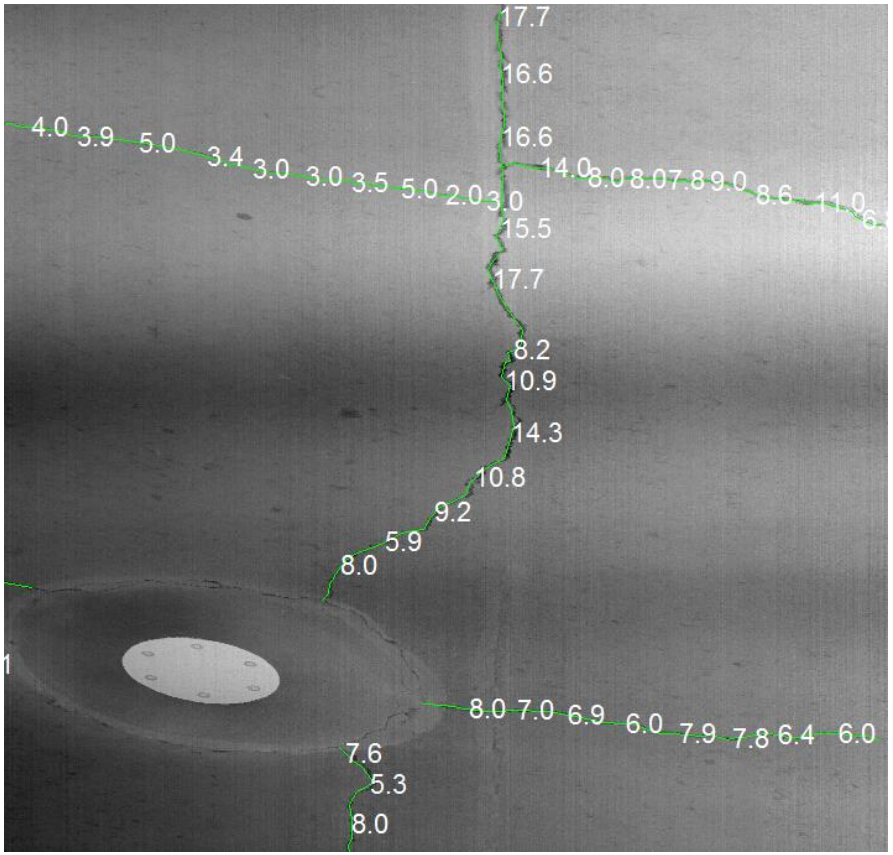


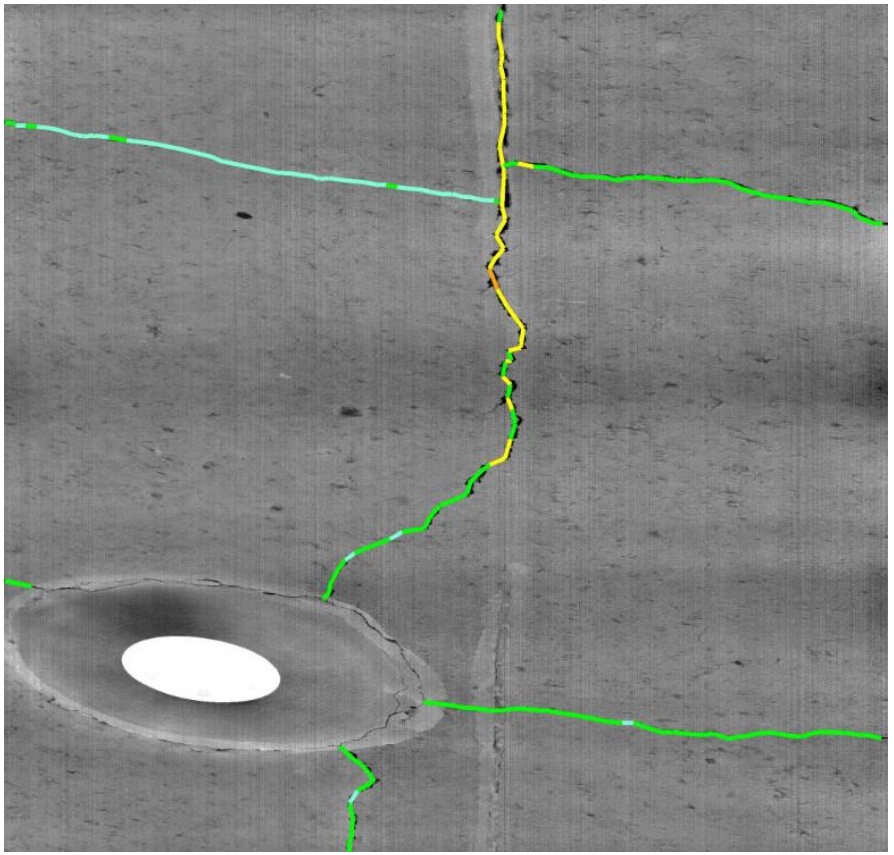
Profile Measure: 15 pixels

Angle Adjustment

Crack Width: 14.2 mm

Color Coded Crack Map

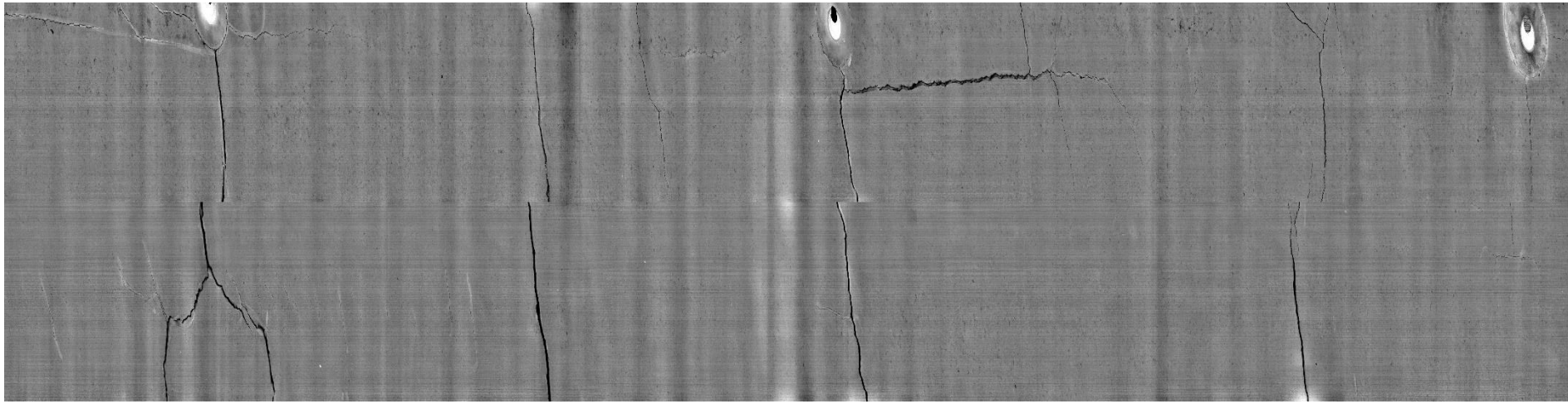


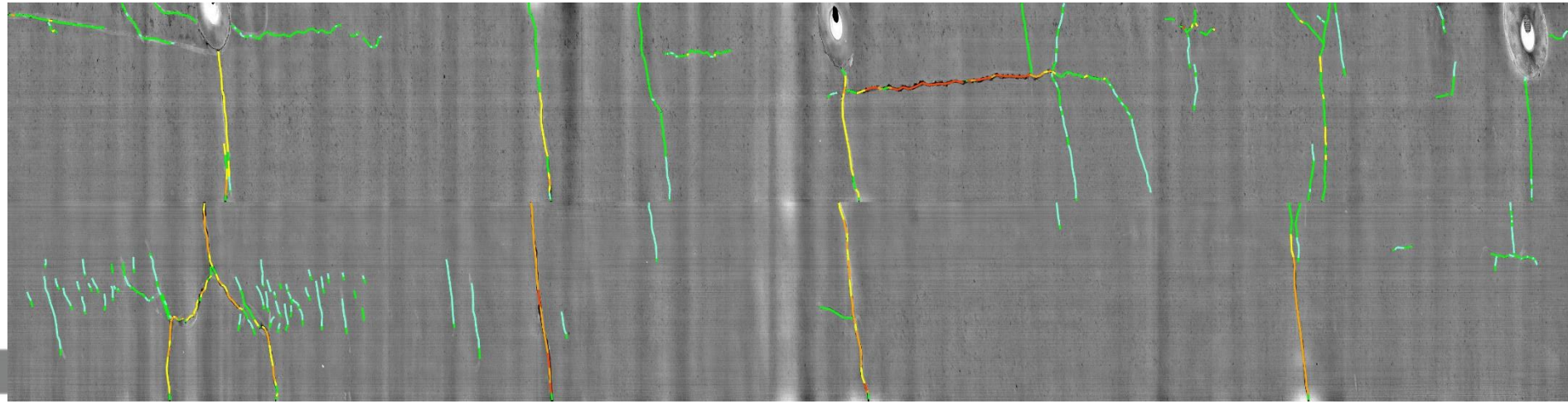


<= 3/16” (3/16”, 1/2”) (1/2”, 3/4”)

(3/4”, 1”) >= 1”

100-ft Section Overview





Estimated Results

Depth for Routing (in.)	Crack Length (m/ft.)
No routing or sealing required	31.7/104
1	32/105
1-1/2	14.3/47
2	19.8/65
Total	97.8/321

Summary

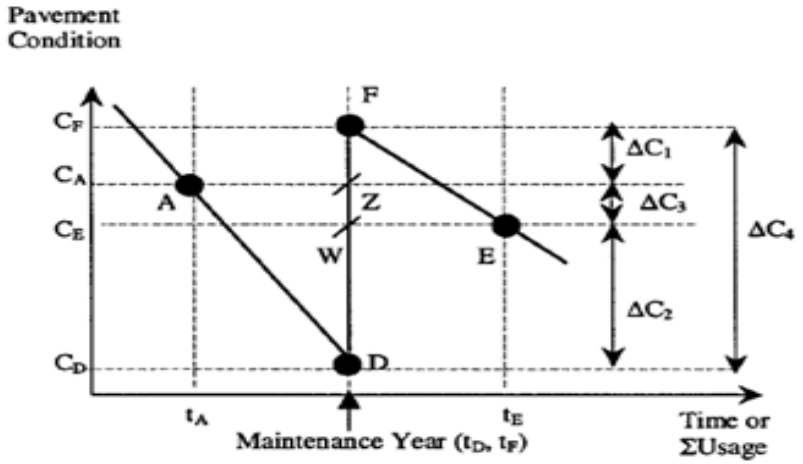
- 3D laser data along with crack detection and crack width measurement is very promising to automate the quantity/cost estimation for crack sealing, which would be very valuable for state DOTs to outsource crack sealing work
- The detailed crack maps with different routing categories can be used by contractors to plan and guide the field work of crack sealing. They can also be used by engineers to conduct quality checking
- Further study is needed to connect fragmented cracks based on crack topology, connectivity, and proximity

Crack Sealing Effectiveness

- (Utah DOT) 75~80% of unsealed cracks developed additional distress vs. 1% of sealed cracks
- (Ontario Ministry of Transportation) Extend 4 years of service life
- (US Army Corps) Extend average 3 years of pavement life
- (FHWA) Extend 0 to 4 years of service life based on 11 projects in 4 states
- (Others) Extend 2 to 5 years of pavement life

Measure of Effectiveness (1)

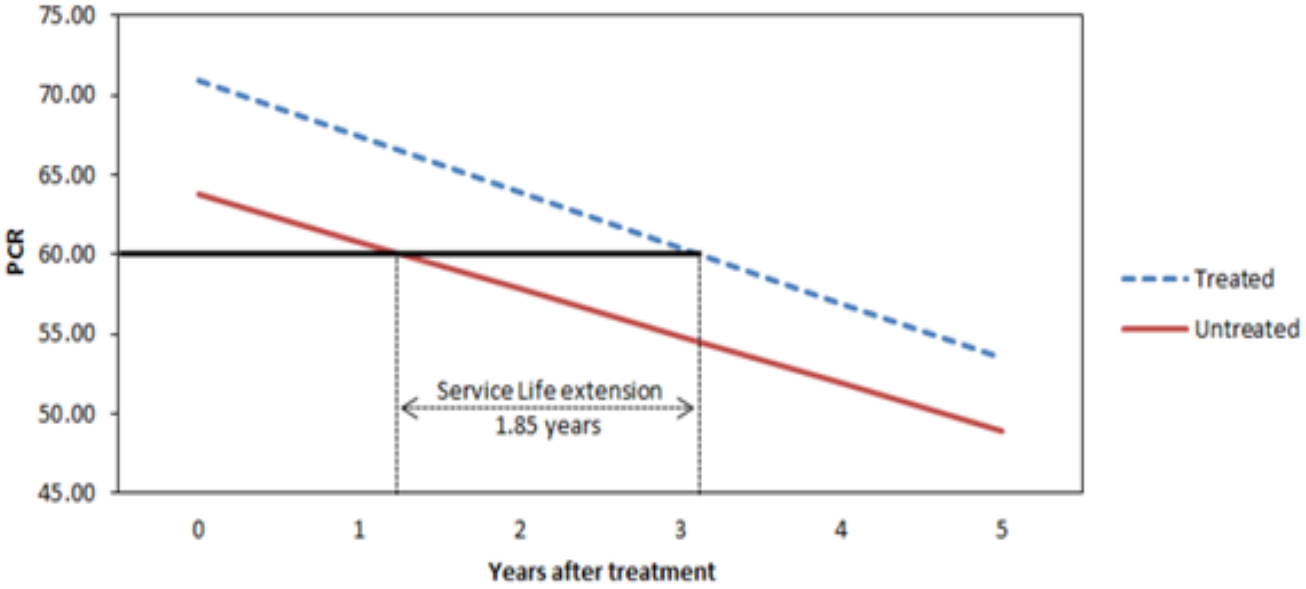
- Short-term performance measure
  - Deterioration reduction level
  - Performance jump
  - Deterioration rate reduction



Labi, S., & Sinha, K. C. (2003). Measures of short-term effectiveness of highway pavement maintenance. Journal of Transportation Engineering, 129(6), 673-683.

Measure of Effectiveness (2)

- Service life extension



Rajagopal, A., Minkarah, I., Green, R., & Morse, A. (2003). Effectiveness of Crack Sealing on Pavement Serviceability and Life: Ohio Department of Transportation.

Measure of Effectiveness (3)

- Percent of effectiveness (FHWA study)
  - Failure of crack sealing
    - Full-depth adhesion or cohesion loss;
    - Complete pullout;
    - Spalls and secondary cracks;
    - Potholes, etc.
  - Percent of effectiveness = (total sealed crack – failed crack)/(total sealed crack) (in length)

Yildirim, Y., Qatan, A., & Kennedy, T. W. (2002). Performance Evaluation of Hot and Cold Pour Crack Sealing Treatments on Asphalt Surfaced Pavements

Factors Impacting Performance

- Application timing
  - Overall pavement conditions
  - Crack type
  - Crack severity level
  - Crack extent
- Crack characteristics
  - Transverse cracks are normally “moved”; thus, crack sealing is applicable
  - Crack filling is usually used on longitudinal cracks
  - Alligator cracks are not suitable for crack sealing because of base failure
  - Too thin or too wide cracks are not suitable for crack sealing (>1/8 in (3 mm) in GDOT is required for crack filling)

What's Next To Do?

- Study of crack sealing effectiveness
  - Data from LTPP
  - Data from GDOT
  - Field test and long-term monitoring
- Network-level crack sealing project prioritization and selection
  - Candidate crack sealing projects are defined by clustering pavement segments with similar crack characteristics
  - Determine cost-effectiveness of each crack sealing project
  - Optimize funding allocation by selecting crack sealing projects that result in optimal return on investment

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Thanks!

Q/A

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