Detecting Asphalt Pavement Cracks under Different Lighting and Low Intensity Contrast Conditions Using 3D Laser Technology

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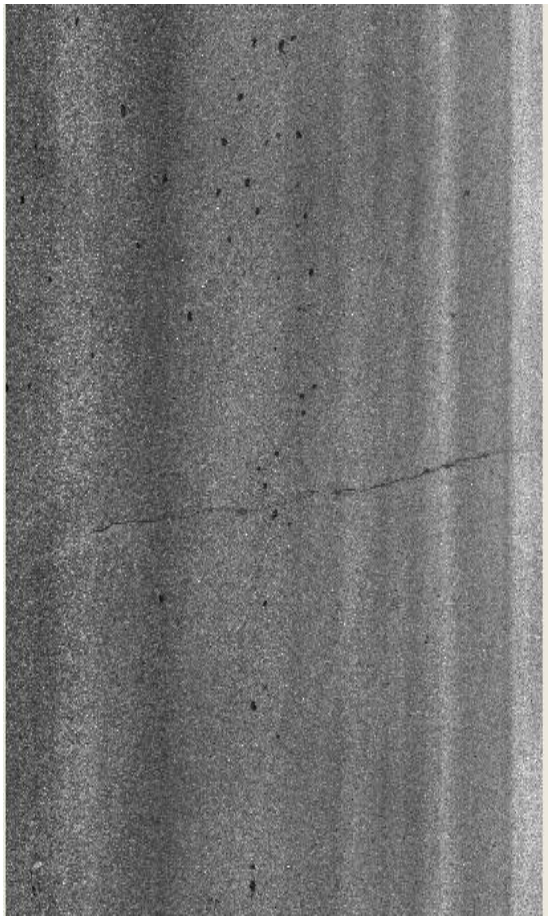
Outline

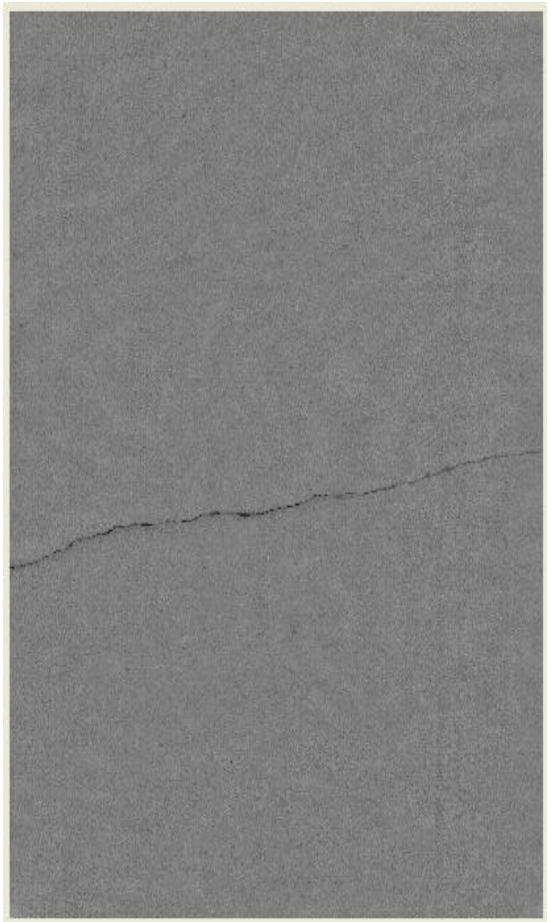
- Motivation
- Research Objectives
- 3D Sensor Technology Introduction
- Proposed Performance Evaluation Method
- Experimental Tests
- Conclusions and Recommendations

Advantage of 3D data over 2D data on crack detection

2D data



3D data

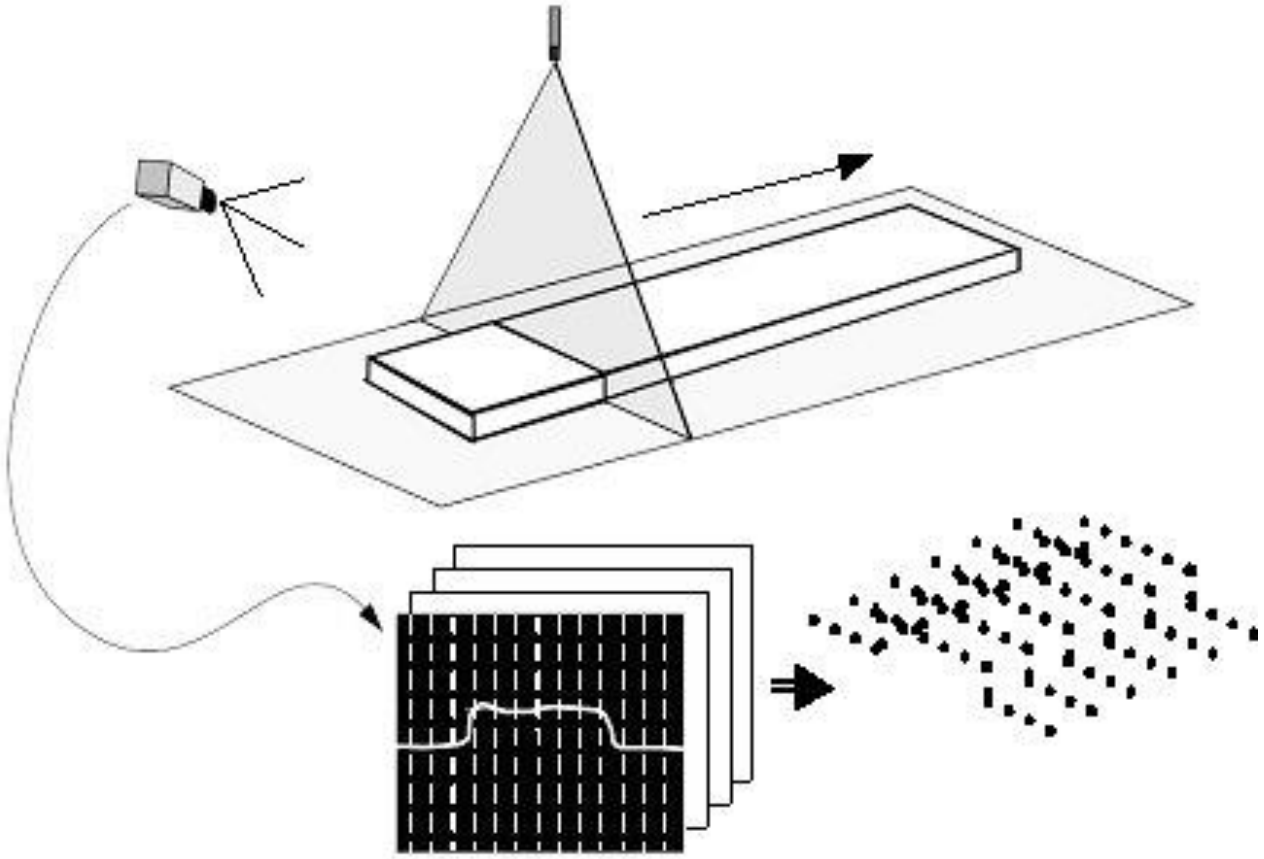


With 3D continuous profile technology, it is a lot more clear to distinguish a crack from the surrounding pavements

Research objectives

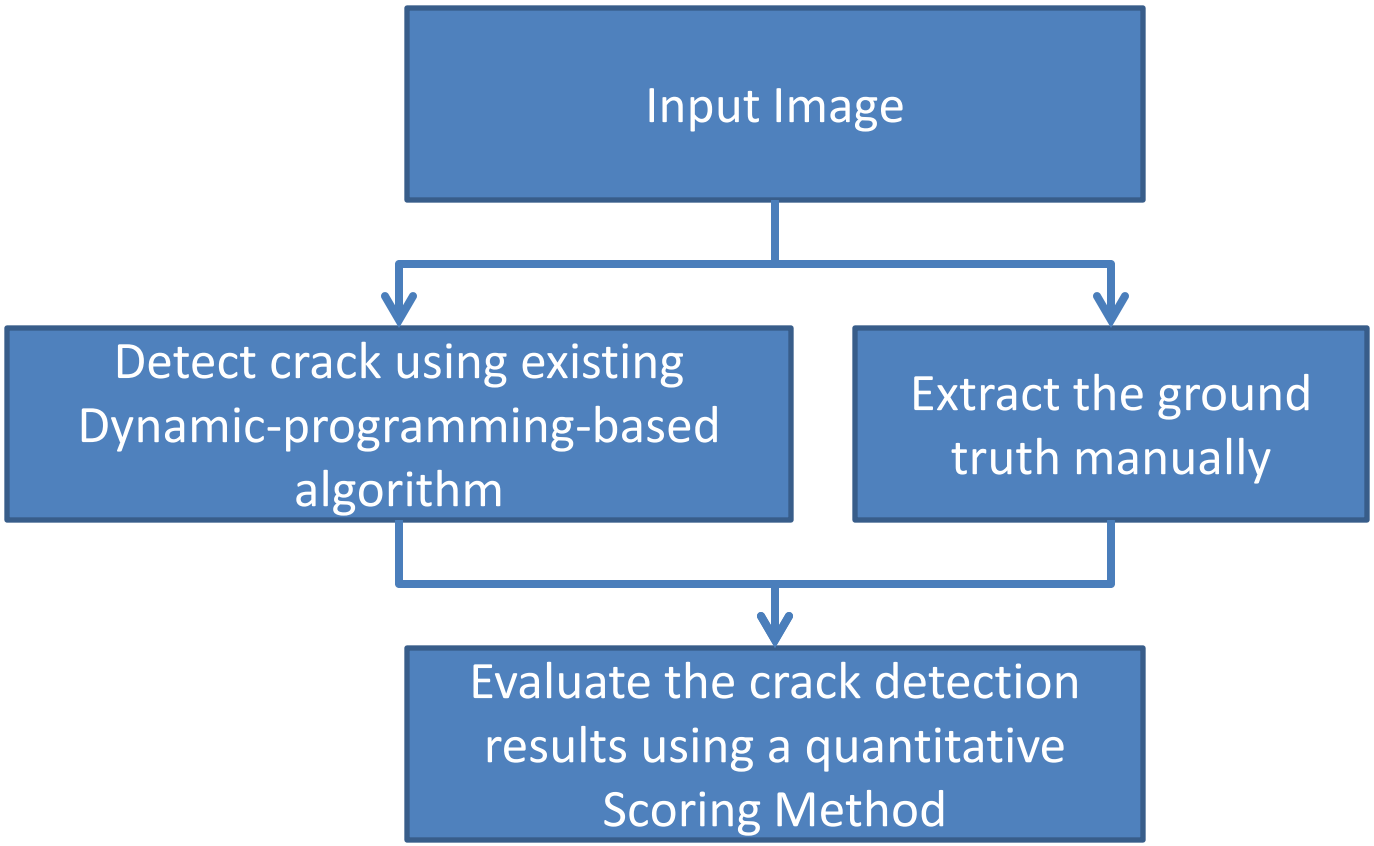
- Evaluate the performance of detecting cracks under different lighting and low intensity contrast conditions using a 3D pavement profile data.
- Evaluate the performance of crack width that can be detected using a 3D pavement profile data.

3D Continuous Pavement Profile Data Acquired using 3D Technology



(Laurent, et. al., 2008)

Proposed Performance Evaluation Method



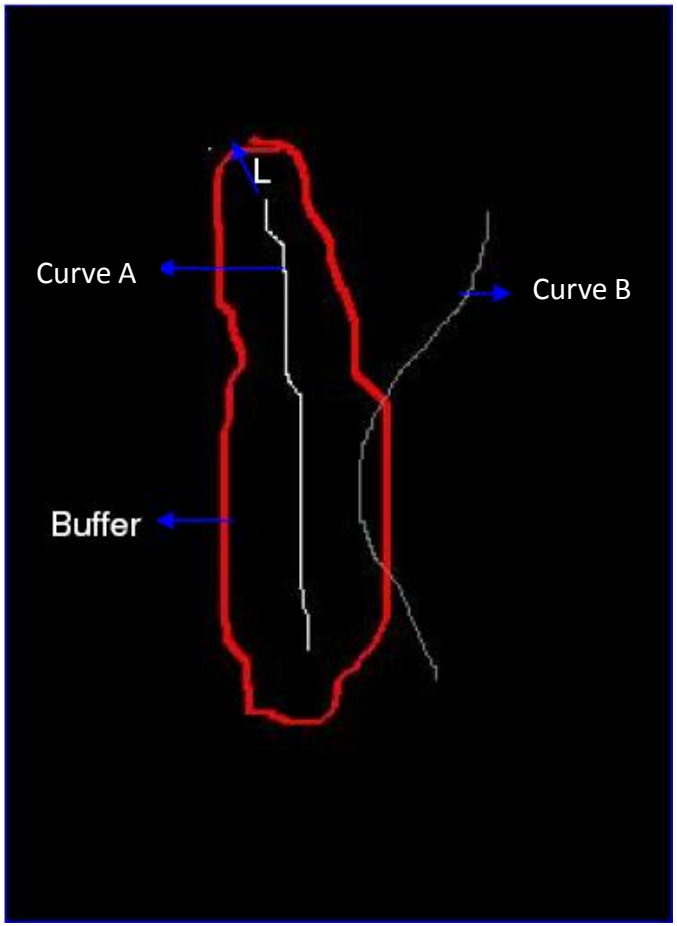
Existing Dynamic-Programming-based Crack Segmentation Algorithm

- Under all possible shapes and positions of the crack indication, one combination is sought to maximize the score function

$$Crack = \arg\max_{(n, p_1, .., p_n)} f(p_1, p_2, .., p_n)$$

- p_i's are coordinates of the pixels along the crack indication
- The dynamic-programming-based algorithm outperformed the other five crack segmentation methods for almost all test images (Kaul et al. 2010)

A Linear Buffered Hausdorff Scoring Method

- 

$$BH(A,B) = \max(h(A,B), h(B,A))$$

$$h(A,B) = \frac{1}{m}\sum_{a\in A} \underset{L}{sat} \min_{b\in B} \|a-b\|$$

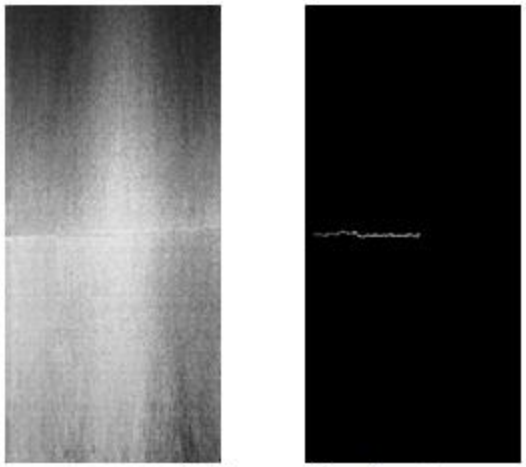
$$\text{Scoring Measure(SM)} = 100 - \frac{BH(A,B)}{\text{L}} \times 100$$

Experimental Test

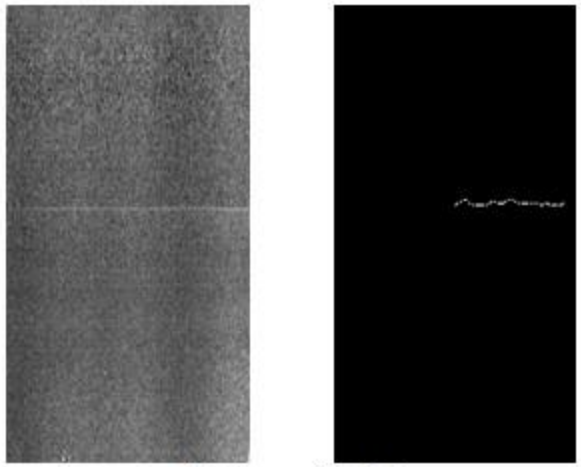
- Laboratory tests
  - Simulated cracks with known widths
    - 1mm, 2mm, 3mm, and 5 mm
  - Daytime and night

- First field tests
  - Ten longitudinal cracks and one transverse crack
  - Daytime (no shadow), shadow, and night
- Second field tests
  - An actual crack with low intensity contrast to the surround pavement background

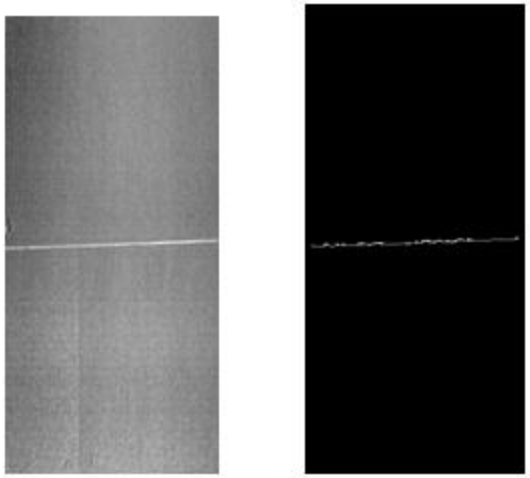
Laboratory Test Result



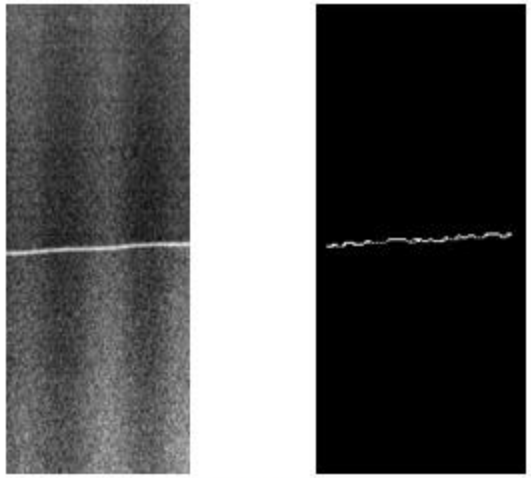
(a) 1mm (daytime)



(b) 1mm (night)

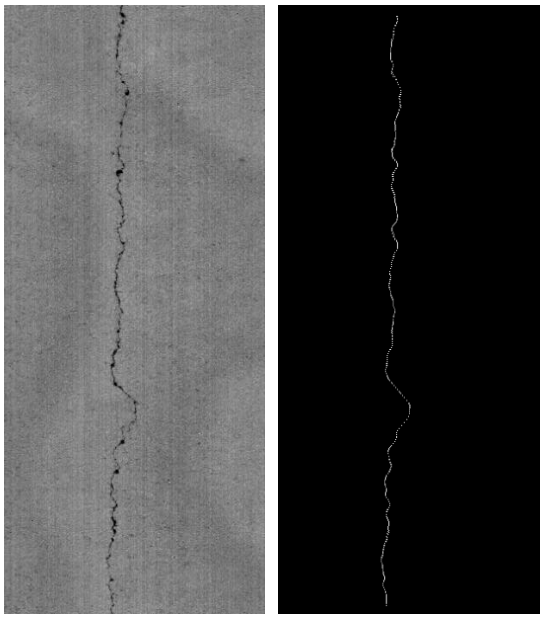


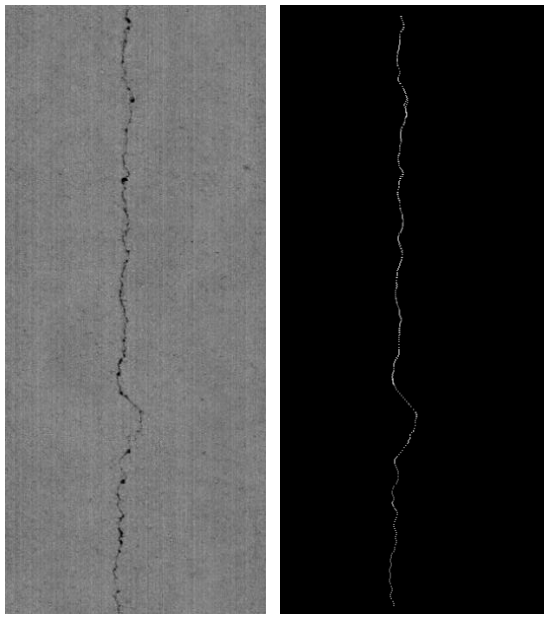
(c) 2mm (daytime)

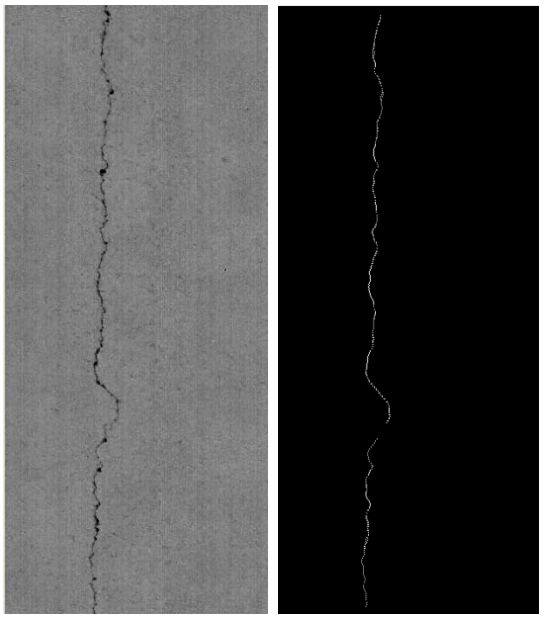


(d) 2mm (night)

First Field Test Results







Daytime (no shadow)

Shadow

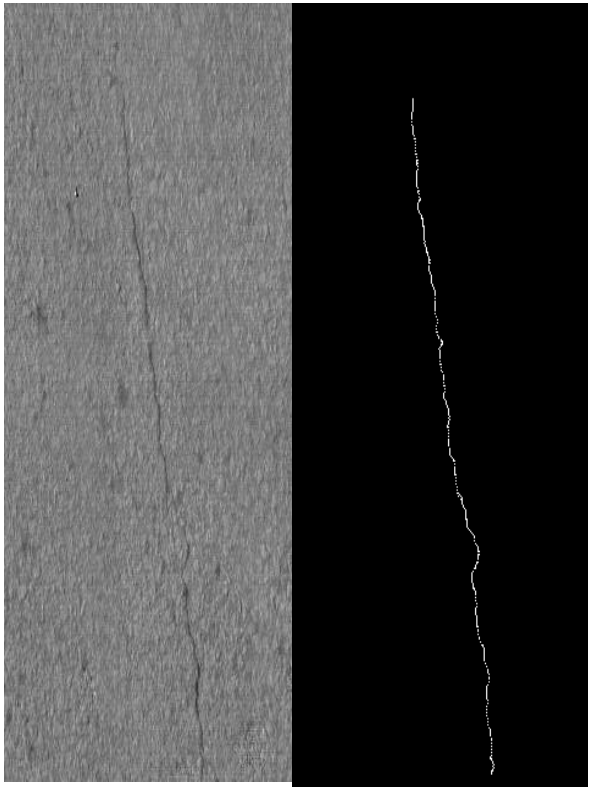
Night

First Field Test Results (Cont'd)

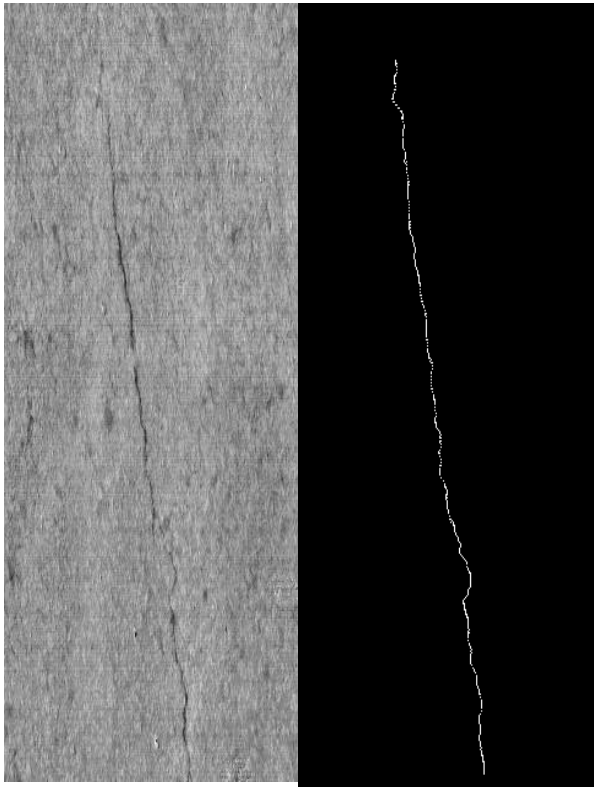
Crack Name	Score			Score Difference
	Daytime	Shadow	Night	
A	97.2	97.4	95.8	1.6
B	95.4	96.1	95.5	0.7
C	97.2	96.8	93.6	3.6
D	96.9	97.2	95.0	2.2
E	97.3	97.8	96.5	1.3
F	97.5	98.0	96.5	1.5
G	97.5	97.7	95.1	2.6
H	97.6	96.6	95.4	2.2
I	97.4	96.3	96.3	1.1
J	97.7	97.6	95.6	2.1
T	97.6	96.9	95.9	1.7

Average Score difference = 1.9

Second Field Test Results



Daytime (score = 98.3)



Night (score = 98.0)

Conclusions

- The proposed system can work consistently under different lighting conditions with the average score difference less than 2 (out of 100).
- The proposed system can potentially detect the cracks under poor intensity contrast conditions.
- Cracks with the width equal to and greater than 2mm can be segmented well from the pavement background, and the 1mm crack can be partially segmented.
- In summary, the proposed 3D laser technology is a promising technology for crack detection.

Recommendations

- A comprehensive test with a large data set, including different asphalt pavement surfaces (i.e. dense graded, open graded pavement, chip seal, and etc.) and different roadway conditions, including oil stains and patches, is recommended.
- Study the optimal 3D sensing system configurations, including the parameters, such as tilt angle (it is 12 degree counter-clockwise), range parameters that might potentially impact the 3D pavement surface data quality and will impact the crack detection capability.

Thank you