Pavement Surface Evaluation beyond Cracking with Deep Learning

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Four Parts

1. From 1mm 3D to 0.5mm 3D
   - Pave3D 8K
2. Deep-Learning based AI System for Automated Cracking Analysis
3. Non-Cracking Analysis with Deep-Learning
4. 0.1mm 3D for Safety Analysis
Part 1: Current Applications of 3D Laser Imaging
Sample 3D Data at 1mm Resolution Collected at 60MPH 10 Years Ago
Sample 3D Data at 1mm Resolution Collected at 60MPH 10 Years Ago
Sample 3D Data at 1mm Resolution Collected at 60MPH 10 Years Ago
Pave3D 8K: the Next-Generation

- More than 8,000 Pixels in 2D & 3D in the Transverse Direction, Covering Full-Lane
- 30KHz Line Rate in the Longitudinal Direction: 1mm longitudinal resolution at 60MPH
- Compatible with Current Deep-Learning Solutions
- Built-In Inertial Sensor for Longitudinal Profiling
- Cracking/Rutting/Patching/Pothole/Sealed Cracking, et al, and IRI
Pave3D 8K in Truck Mount
New Sensor Design
Sample Data of Manhole, Full-Lane 2D
Sample Data of Manhole, 2D & 3D
Sample Data of Manhole, Zoomed-In 2D
Light Reflector, Full-Lane Width
Light Reflector, Zoomed-In 2D
Light Reflector, Zoomed-In 3D
AI Analysis based on Deep-Learning

- Pixel Level Recognition
- Deep-Learning based Neural Network
- Big-Data with Parallel Processing
- Stability, Consistency, High-Speed, and Accuracy
Learning Database: Critical for Successful Learning
CrackNet: from Training to Operation

Input Image

Ground Truth with Pixel-Perfect Accuracy

DL Network

Recursive Training

Detection Output with Pixel-Level Accuracy
Pixel Level Intelligence

Automated Pixel-level Pavement Crack Detection on 3D Asphalt Surfaces with a Recurrent Neural Network [J], *Computer-Aided Civil and Infrastructure Engineering*, [https://doi.org/10.1111/mice.12409](https://doi.org/10.1111/mice.12409).
First-Gen CrackNet

- 7 Layers
- 1,159,561 Parameters
Sample Results of 1st Gen CrackNet
Samples of 2\textsuperscript{nd} Gen CrackNet

Best CrackNet

Best CrackNet + RNN
CrackNet on Concrete Pavements

普通水泥路面

含路面刻槽(Groove)的水泥路面
Key Advantages of CrackNet

- Stability of Recognition
- >90% P & R
- Accumulated Learning
- NOT Based on Analytical Modeling
Other Non-Cracking Features: Markings, Man-Hole, Bridge Expansion Joint
DL based Marking Identification
Pothole Identification
Patching Identification
Sealed-Cracking Identification
0.1mm 3D Laser Imaging for Safety
Non-Contact 0.1mm 3D Imaging for Continuous Safety Evaluation

- Pavement Safety
  - Micro/Macro Texture, Friction
- Current Contact-Based Friction Testers
  - Decades old std, Contact/Water, Tire Wear
  - Large Variations in Consistency, Repeatability
- 0.1mm non-Contact Approach, Possible
- Critical
  - Data Quality, Processing Methods
Samples of 0.1mm 3D Pavement Surface
Samples of 0.1mm 3D Pavement Surface
Conclusions

- Sub-mm (0.1mm to 0.5mm) 3D Data & Processing Tech
- Next-Gen & Next 10 Years
- Comprehensive: Condition, Function, Safety
- 5G/BIM/Cloud/VR/Exascale Computing: many available platforms
- Most Critical: Solutions to Users