Automated Pavement Distress: Proven Technology and Procedure

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Automated Pavement Distress

• Why?
  – Safe
  – Objective
  – Repeatable
History

• Data Acquisition
  – Lasers
  – Areas scan cameras
  – Line scan
  – 3D imaging?
... History

- Processing
  - RISC processors
  - Standard workstation using NT & XP
  - FPGA
  - Standard workstation using XP & Vista
  - More sophisticated algorithms & increased image size & resolution
... History

• Testing and Evaluation
  – Limitations vs. Capabilities
  – Emphasis on what CAN’T be done instead of what CAN be done
  – Delayed acceptance and implementation
  – Good or bad?
Now ...

- Proven
  - Used world wide (public and private agencies)
  - Many 100’s of thousands miles processed
Key Components

- Image Acquisition
- Image Processing
- Quality Assurance & Quality Control
  - About procedures and processes as much as it is about the product
Image Coverage

- 4 m (13 ft) lane width
- 100% continuous imaging at 62 mph
- Analog → Digital → Line scan cameras
- 3 → 2 → 1 mm pixel resolution
- 0.16 → 0.48 → 1.6 GB per mile
Image Capture

- Real-time stitching
  - Longitudinally
  - Transversely

- Continuous coverage saved in 52.8 ft intervals
Image Capture

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  - Longitudinally
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Lighting

• Eliminate shadows
  – Trees
  – Building
  – Signs

• Cast shadows
  – In the cracks
  – Provide contrast
Assumption:
For Crack Detection

- Crack – continuous black line(s)

- Is this assumption true?
  - Yes for most cases
  - No for some cases
Illumination Angle

\[ h = w \times \tan(\theta) \]

<table>
<thead>
<tr>
<th>( \theta )</th>
<th>w (mm)</th>
<th>1 (mm)</th>
<th>2 (mm)</th>
<th>3 (mm)</th>
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<tr>
<td>30°</td>
<td>0.58</td>
<td>1.16</td>
<td>1.74</td>
<td></td>
</tr>
<tr>
<td>45°</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>64°</td>
<td>2.05</td>
<td>4.10</td>
<td>6.15</td>
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Crack is filled with dirt / dust.
Crack edges are worn or missing.
In images we get ...

Less than actual crack size
(smaller in width, if it is smaller than pixel size, it tends to be broken)

Less contrast (blurry, hard to detected)
Surface cracking

- Mostly found on rough texture surface (heavily broken in the figure).
- Sometimes, the crack can be seen in ROW, but not in pavement video.
Other difficulties

• Rough texture surface
Visibility and detection is difficult & variable

- Random direction of cracks vs. directional lighting.
- Random depth of cracks vs. random shadows representing crack width.
- Random missing crack edge vs. random shadows representing crack width.
What does this mean?

- Difficult to detect wide cracks
- Difficult to detect narrow cracks
- Difficult to detect cracks without depth

- Crack detection is a DIFFICULT task
Image Processing

- Automated crack detection
- Classification
- Rating
- QA / QC
WiseCrax

• Detailed crack attributes
  – Location
  – Type
  – Severity
  – Extent
  – Density

• 100% Coverage
• Flexible classification scheme
Project Set-up

- Road zones
  - Lane width (automatic)
  - WP widths
  - Edge width
  - Etc.

- Rating scheme
  - Select
  - Edit
Crack Detection

- Parameter setting
  - Signal to noise ratio
  - Crack grouping
  - Noise limits
  - Crack length
Classification

- Shoulder
  - Center Line
  - Longitudinal Cracks

- Shoulder
  - Center Line
  - Transverse Cracks

- Shoulder
  - Center Line
  - High Severity
  - Medium Severity

- Shoulder
  - Center Line
  - Block Cracks
Parameter Setting

- Classification schemes
- Crack type
  - Longitudinal
  - Transverse
  - Block
  - Alligator
Classification Result

- Green – longitudinal
- Blue – transverse
- Blue Edges – auto detected lane width
Rating Scheme

Rating Category #1

Category Detail #1
- Location Options
  - Left wheel path
  - Right wheel path
  - Lane Center
  - Left pavement edge
  - Right pavement edge
- Severity Estimation Parameters
- Metric Options

Rating Category #2

Category Detail #2
- Location Options
  - Left wheel path
  - Right wheel path
  - Lane Center
  - Left pavement edge
  - Right pavement edge
- Severity Estimation Parameters
- Metric Options

Rating Category #3

Category Detail #3
- Location Options
  - Left wheel path
  - Right wheel path
  - Lane Center
  - Left pavement edge
  - Right pavement edge
- Severity Estimation Parameters
- Metric Options
Rating

- Schemes
- Categories
- Details
- Metrics

- Provides flexibility
Batch Processing

- Parameters for a given pavement;
  - Type
  - Condition
  - Level of distress

- Assign parameter set for given sections
- Process
- Review
Usage

• 100% Automated
  – SCANNER Surveys (U.K.)
  – Various State DOTs (MD)
  – Network operation (typical)

• Manual intervention
  – To see 100% of cracks
  – Remove false positives
  – Project level (typical)
• Detection is not perfect
• Series of steps and procedures for validation
  – Collection
  – Processing
  – Indices
Future

• Always getting better …
  – Algorithm improvements
    • Increase in detection rate
    • Reduction in false positives
  – Faster processing
  – 3D data augmentation
Thank you ....

... Questions?