DETECTING LOCALIZED ROUGHNESS USING DYNAMIC SEGMENTATION

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The C-LTPP project

- The C-LTPP Project includes 24 test sites constructed between 1989 and 1991.
- Each site has 2 to 4 adjacent test sections for a total of 65 test sections.

Location and identification of C-SHRP LTPP test sites.
C-LTPP profile data

- Profile measurements taken manually with a dipstick on annual basis.
- Dipstick foot spacing is 300 mm for most of the sections.
- The survey closure error was redistributed over all the measurements recorded.

Schematic for the dipstick profiling process
Objectives

- To develop guidelines for analyzing the measurement of longitudinal pavement profile using two dynamic segmentation methods;

- To demonstrate the benefits of refining the monitoring of pavement conditions; and

- To Propose a model for estimating the required interval for reporting roughness profiles.
The roughness profile for the OWP of the test site 810404 (prior to overlay 09/06/1990)
Significance of Roughness Profile Segmentation

12 out of 1332 profiles have an IRI range smaller than 1.0mm/m.

The frequency distribution of IRI range (1332 section profiles)
The cumulative difference approach (CDA)

(a) Response

(b) Cumulative Area

(c) Cumulative Differences
The absolute difference approach (ADA)

\[ Z_i = |r_i - r_d| \]

Average response
Segment length
Response range

\[ r_d \]
\[ r_i \]
\[ x_i \]
\[ x_d \]
Illustrative Example

(a) ADA Segmentation

(b) CDA Segmentation

(c) Cumulative Area

(d) Cumulative Differences

Segmentation Example

Pavement Response, $r_i$

Segment Length

Cumulative Area, $A_x$

Segment Length

Cumulative Difference, $Z_x$

Segment Length

(-) (+) (-)

Border

Border

Pavement response range

ADA Segments

CDA Segments

Response range
Combining Segments

Each two adjacent segments will be combined into one segment if the difference between the maximum and minimum does not exceed the target range according to the following:

$$\left| r_i^1 - r_j^2 \right| \leq r_{Range}$$  \hspace{1cm} for all  \hspace{1cm} x_i, x_j

Where:

- $r_i^1$ is the response $r_i$ at $x_i$ for segment 1.
- $r_j^2$ is the response $r_j$ at $x_j$ for segment 2.
- $x_i$ is any distance within segment 1.
- $x_j$ is any distance within segment 2.
- $r_{Range}$ is the specified target response range.
# Statistical Comparison

## TABLE 1 General Statistical Summary for Segment Lengths (m), CDA Approach

<table>
<thead>
<tr>
<th>Statistic</th>
<th>IRI Range (m/km)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.2</td>
</tr>
<tr>
<td>Mean of segment lengths</td>
<td>7.01</td>
</tr>
<tr>
<td>Standard Error</td>
<td>0.06</td>
</tr>
<tr>
<td>Sample Variance</td>
<td>92.22</td>
</tr>
<tr>
<td>Count</td>
<td>24466</td>
</tr>
</tbody>
</table>

## TABLE 2 General Statistical Summary for Segment Lengths (m), ADA Approach

<table>
<thead>
<tr>
<th>Statistic</th>
<th>IRI Range (m/km)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.2</td>
</tr>
<tr>
<td>Mean of segment lengths</td>
<td>4.91</td>
</tr>
<tr>
<td>Standard Error</td>
<td>0.04</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>8.01</td>
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<tr>
<td>Sample Variance</td>
<td>64.09</td>
</tr>
<tr>
<td>Count</td>
<td>34328</td>
</tr>
</tbody>
</table>
The roughness profile corresponded with segmentation data for test site 810404
Relationship between segment length and IRI range
TABLE 3 Models for Correlating IRI Range (m/km) and Reporting Interval (m)

<table>
<thead>
<tr>
<th>Model</th>
<th>Equation</th>
<th>$R^2$</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear</td>
<td>$L = 21.2 IRI_{range} + 3.1$</td>
<td>0.92</td>
<td>1.29</td>
</tr>
<tr>
<td>Logarithmic</td>
<td>$L = 8.8 \log_e( IRI_{range} ) + 20.4$</td>
<td>0.98</td>
<td>0.54</td>
</tr>
<tr>
<td>Quadratic</td>
<td>$L = -42.5 IRI^2_{range} + 59.4 IRI_{range} - 4.3$</td>
<td>0.99</td>
<td>0.09</td>
</tr>
</tbody>
</table>
Conclusions and Recommendations

- A sample of 1332 roughness profiles has been analyzed to evaluate the effect of localization of roughness values.
- Two methods for segmenting profiles were used.
- ADA method is recommended when IRI range is required because CDA may provide some segments that have IRI range outside the required range.
Segments were combined based on different values of IRI range starting from 0.2 m/km to 0.7 m/km.

The relationship between IRI range and segment length is estimated.

A quadratic mathematical model is introduced to estimate the required interval for reporting roughness profiles.
Thank You