Developing the automatic measurement of surface condition on local roads

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Measuring condition at traffic-speed in the UK

- **UK condition surveys measure**
  - Longitudinal profile
  - Transverse profile
  - Texture profile
  - Cracking (automatic)
  - Geometry

- **Annual coverage**
  - TRACS: 40,000km motorway and trunk roads
  - SCANNER: 80,000km local road network

- **Surveys carried out to an end result specification**
Accredited Systems:
- Jacobs
  - Ramboll RST26, RST27
- WDM
  - RAV1, RAV2, RAV3, RAV4
- DCL
  - Roadware ARAN1, ARAN2

Portorož, Slovenia
UK local roads (rural) - SCANNER

Portorož, Slovenia
UK local roads (urban) - SCANNER
Use of the Data

- **Local use**
  - Parameters reported over 10m lengths for local use

- **Network use**
  - For trunk roads total length of poor values reported
    - Single HA performance indicator (PI)
  - For local roads a Road Condition Index (RCI) is produced every 10m
    - Reports “overall” condition score
    - Distribution of RCIs over the local authority defines network condition (LA Indicator)
  - Potential use in allocation of funding across authorities
Enhancing the use of data from local roads

- Local roads differ from trunk roads
- New methods required to maximise value of local road data
- Research to improve the use of the survey data
  - Measuring ride quality on local roads using shape data
  - Using texture to assess surface deterioration on local roads
  - Measuring edge deterioration on local roads
- Work concentrated on the use of shape data
- Began with consultation to find out what users needed in practice
“Shape” data collected at traffic-speed

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Consultation with engineers found that
- Little importance placed on longitudinal profile data
- Key structural measure is cracking and rutting
- Engineers desire a **reliable** assessment of **general ride quality** (functionality)
- But engineers key concern is defects giving rise to **bumps** (user complaints)

Concluded that methods needed to
- Reliably identify lengths with poor ride quality
- Identify general locations giving rise to bumps
Measuring ride quality - data collection

- A practical investigation to relate surface profile to user opinions on local roads
- Several routes surveyed, including sections known to be poor
- Profile data provided by HARRIS1 profilometer
  - Measurements in both wheel tracks (and across survey width)
- User surveys:
  - Car surveys
  - Motorbike survey
  - Utilising on-board data collection with GPS referencing
  - Reported on ride and bumps
  - Repeat surveys for consistency
Considering general ride quality

- Wavelet Decomposition
- PSD
- IRI, Ride Number, Profile Index
- MA and enhanced variance
- Coefficient de planeite
- Waveband Energy
- Standard Deviation

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General ride quality - wavelength response

- IRI
- 3m Variance

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Parameter for general ride quality

- Predicting general ride quality on local roads
  - 1-5m wavelength features cause the users most discomfort.
  - **3m enhanced variance** agreed best with user opinion of underlying ride quality. Other measurements agreed no better with the user’s opinion.
  - **10m enhanced variance** showed some agreement (effects of longer wavelengths on truck drivers).
  - Wavelengths over 20m - little or no agreement with user opinion.

- Effect of measurement (line)
  - Offside measurements contributed to 33% of agreement with user opinion.
  - Multiple measurement lines around the wheelpath did not improve agreement.
Measuring “Bumps” on local roads

- User surveys recorded bumps using button presses.
- Wavelet analysis suggested wavelengths of interest lie between 1 and 3m.
- Existing measurements (variance, IRI etc) did not reliably report the locations of the features causing this bump-like discomfort.

![Diagram showing normalised power vs wavelength with button press and no button press markers.](image-url)
Measuring “Bumps” on local roads

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A parameter for “Bumps” on local roads

- Considered many approaches, e.g.
  - 1.25m enhanced variance, change of vehicle acceleration, derivative of longitudinal profile (features too small to impact on a car’s tyre)

- The Central Difference Method
  - Calculates a “derivative” for each point along the road (profile measurements \{y_i\}, taken at distances \{x_i\} along the road):

  \[ F'(x_i) = \frac{y_{i+1} - y_{i-1}}{x_{i+1} - x_{i-1}} \]

  - Similarly for \(F''\).
  - The maximum of these values is calculated over 1m lengths.
  - If \(\text{max}(F')\) and \(\text{max}(F'')\) both exceed set thresholds, then the length contains a bump and a value of “1” is reported for that length. Otherwise “0” is reported.
Measuring “Bumps” with the CDM – local roads

- Tests to review locations where the bump measure responded
  - Reported 84% of user button presses.
  - Potential high number of false positives.
  - Inspection of 3D profile and video showed features of note where CDM responds, but users had not always pressed the button.

- Concluded
  - This is an appropriate method for identifying “bumps”.
  - We should use a combination of this and 3m enhanced variance for assessing general ride and bump density on local roads.
Testing on trunk roads

Easting and Northing

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Measuring “Bumps” – trunk roads

- Applied to whole of trunk road and motorway network.
  - 0.17% of network reported to contain bumps

- Subset inspected in closer detail:
  - Inspected 3D profile for 10% of locations
  - Visual inspection on site of 1% of locations

- Where 3D profile inspected:
  - 87% contained obvious bumps
  - Further 10% showed general unevenness

- Where site inspected,
  - 64% showed visible bumps on site
  - 24% were not “bumps”, but were poor bridge joints
  - 3% were bumps at surface change
Measuring Edge deterioration - consultation

- Consultation with engineers found that
  - Edge deterioration universally considered an area for concern
  - Key requirement for a measure to aid in defining maintenance treatment
- Features of interest
  - Potholes in surface near edge
  - Overriding
  - Cracking of surface near edge
  - Edge supported or kerbed
  - Presence of patching
Developing parameters for Edge Deterioration

- A fully automated measure
- Utilising transverse profile data
  - Firstly Identify the edge strip
- Edge Roughness
  - Roughness within the edge strip
- Edge Stepping
  - Stepping at the nearside of the edge strip
- Transverse Variance
  - Assessing roughness across the pavement
Edge deterioration parameters

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The Edge deterioration parameters

- Transverse unevenness
- Edge roughness
- Edge step

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Testing the Edge deterioration parameters

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An Indicator for Edge Condition

- Four parameters provide a complicated picture of condition
  - Better to report the general edge condition
- The ‘Edge Deterioration’ indicator
  - Combines all four SCANNER Initial Edge Deterioration Parameters
  - Is a weighted combination of parameters after applying thresholds and normalisation
  - Provides a single number to the engineer
  - Is based on the logic of the SCANNER RCI

\[ \text{Edge Det} = W_{\text{ry edge roughness}} + W_{\text{tv trans variance}} + W_{E1 \text{ edge step 1}} + W_{E2 \text{ edge step 2}} \]
Testing the indicator for Edge Condition

Comparison with site assessments

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Testing the indicator for Edge Condition

- Proportion of roads having significant edge deterioration by manual surveys and the Edge Deterioration Indicator

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Conclusions

- Traffic-speed surveys have become widely applied in the UK on local roads under SCANNER (>100,000km/year)
- Local roads have particular defects
- A research programme has developed a set of parameters for reporting local road condition using data collected at traffic-speed
- For ride quality
  - Enhanced variance
  - A bump measure
- For edge deterioration
  - A set of edge deterioration parameters
  - An edge condition indicator
- These new parameters were introduced into SCANNER in 2007 for network level reporting