AUTOMATED RAVELING INSPECTION AND MAINTENANCE PLANNING ON POROUS ASPHALT IN THE NETHERLANDS

FIRM15 - Brussels

contact: willem.vanaalst@tno.nl
INTRODUCTION

- Willem van Aalst, TNO
  - System engineer & project manager (infra inspection)

- Automated raveling inspection and maintenance planning on porous asphalt in the Netherlands

Project(s) performed under authority of:
- The Dutch Highway Agency, Ministry of Infrastructure and the Environment
CHALLENGES

- Porous Asphalt (ZOAB):
  - Dutch highways: > 85% ZOAB
  - ZOAB 0/16: > 70%

- Raveling:
  - Loss of aggregates
  - Dominant failure mechanism (>90%)

- Alternative for visual inspections:
  - Objective, Safe, Cost
  - Road width (# lanes)
  - Point laser(s) not sufficient (Stone(a)way)

Source: www.bergersmeeting.com/nieuws.htm
GENERAL CONCEPT

3D data generation

Raveling

Asset management
TIMELINE

- 2009 - 2010: Feasibility
- 2010 - 2011: Proof of concept
- 2012 - 2013: First generation
- 2013-2014: New vehicle
- 2014-2015: Update (colour)
FEASIBILITY PHASE

Questions:
- Raveling from 3D surface?
- Possible at high speed?

Test location: A65:
- 15 sections (1m²)
- Visual inspections
- 3D surfaces
FEASIBILITY PHASE

Simulation of measurement systems

State of the art systems:
- Laser triangulation (1 or 2 spots)
- Laser triangulation (2 lines)
- Amplitude phase modulation lasers

Selected: line laser triangulation
- LCMS sensors (INO/Pavemetrics)
PROOF OF CONCEPT

› 2009 - 2011

Sections
N = 676 (each 100 m)

RWS ARAN 2 equipped with the LCMS system

Test objects used to validate system specifications
PROOF OF CONCEPT

› Visual versus Model:

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› Good correlation with visual inspections!
› 93% (+/- 1 year)
FIRST GENERATION

Main components

› LCMS sensors & controller (3D data)
› Laser Safety Controller (tilt, speed, …)
› RTK – GPS (positioning)
› DMI (triggering)
› Front- & side camera’s (reference)
› FPGA framegrabber (HW timing)
› Acquisition pc (Windows)
› Control pc (Unix)
SPECIFICATIONS

- High speed ‘in-traffic’ measurements
  - ~120 km/h
  - Lane wide: 4 meters

- 3D range data
- 2D intensity data

- Resolution:
  - 1.0 mm (transversal)
  - 4.7 mm (longitudinal)

- Accuracy (height):
  - ~ 0.5 mm (σ)
EXAMPLE DATA

Range

Intensity

3D print
DATA PROCESSING

Steps

1. Road-marking detection
2. Flattening (road & vehicle motion)
3. Texture analysis (pavement type)
4. Removal of:
   • Mechanical damage (rim marks)
   • Joints
5. Wheel path (maximum damage)
6. Raveling (per m² in wheel path)
   • % stone loss
   • % clustered stone loss
PAVEMENT TYPE CLASSIFICATION

- Dependencies on pavement type
  - Raveling
  - Maintenance interval

- Two approaches:
  - Spectrum based (FFT)
  - Texture based (various descriptors)

Porous Asphalt
0/16 mm - 4/8 mm
PAVEMENT TYPE CLASSIFICATION

Examples:

**Spectrum analysis**

**Texture analysis**
PAVEMENT TYPE CLASSIFICATION

- Classification
  - 11 texture measures
  - Quadratic classifier

- Evaluation set
  - $N = 27,128$ (100m)

- Results
  - Overall: $> 98.8\%$ correct
  - Porous Asphalt: $> 99.7\%$ correct
RAVELING

- Flatten & clean data

- ‘Coin’ algorithm
  - Radius \( (r) \)
  - Depth \( (d) \)

- ‘3D Stone(a)way’
RAVELING

› Repeatability:
  › Very good!

› Reproducibility:
  › Very good!
MAINTENANCE INTERVAL

› ‘Old’ style:
  › Visual inspections ➔ Maintenance interval (year)

› ‘new’ style:
  › Ravelling data ➔ Maintenance interval
MAINTENANCE INTERVAL

- Input:
  - Ravelling per m² (both wheel paths)

- Linear classifier
  - 28 inputs → 1 output (per 100m)
  - Trained on visual inspections
**MAINTENANCE INTERVAL**

- **Results:**
  - 2012: ~ 99% correct (+/- 1 year to visual inspection)

- Two districts: Venlo & St. Joost
- Visual inspections

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Rijkswaterstaat
Ministry of Infrastructure and the Environment

23 April 2015
Results:

2014

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ZOAB(+) Total: 230 262 477 593 1622 4365 34675
SUMMARY

› Accurate measurement of raveling on PA (ZOAB)
  › High speed and ‘in-traffic’
  › Good repeatability and reproducibility

› System operational since 2012
  › Replacing most visual inspections

› Modelling of maintenance interval
  › Based on raveling

› Accurate pavement type classification
ONGOING & FUTURE RESEARCH

- Cracking on PA (ZOAB)
- Raveling on fine PA and SMA
- Commercialisation
- (EU-)collaboration
- (Standardisation)
CHALLENGES FUTURE

› Variety in pavements versus Monitoring & Prediction

› Fine porous asphalt versus Measurements
THANK YOU FOR YOUR ATTENTION

Willem van Aalst

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