CROWDSENSING AS A TOOL FOR UP-TO-DATE ROAD ASSET DISTRESS DETECTION
IN COOPERATION WITH

TU Delft

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INTRODUCTION
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Slecht wegdek Haringvlietbrug

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Het verkeer moet de komende weken rekening houden met enige vertraging op de A29 bij de Haringvlietbrug. Vanwege een slecht wegdek zijn ze daar bezig met werkzaamheden.

Hinder

De komende 2 a 3 weken is Rijkswaterstaat bezig met het repareren van het wegdek. Vanwege deze werkzaamheden kan het verkeer ook na de spits enige hinder ervaren. Het wegdek wordt in beide richtingen vernieuwd en daardoor moet het verkeer in beide richtingen dus rekening houden met files en vertraging.

Snelheidsbeperking

Vanwege de werkzaamheden geldt daar de komende weken een snelheidsbeperking.
A CURRENT SCENARIO IN ASSET MANAGEMENT

John

Introduction  Research approach  Implementation  Results  Conclusion  Future work
A CURRENT SCENARIO IN ASSET MANAGEMENT
PROBLEM STATEMENT

- Contracts shift to performance based contracting
  - Contractors bear risks

- Reliability & availability needs to be guaranteed
  - Additional information is needed
A FUTURE SCENARIO

Degradation = ?
State now = ?
A FUTURE SCENARIO
RELATED WORK - CROWDSENSING

- **Roadroid** calculates road roughness per road length and classifies it.
- **Nericell pothole detection** sends detection - multiple detections define a hole.
- **Streetbump** sends detection + data - multiple detections define a hole.
RESEARCH QUESTION

To what extent can the current state and the degradation of a road pavement asset be measured using mobile crowdsensing?
**SCOPE**

- Collect data through premade app
- Along the Dutch highway system
- Focus on Single lane
- Phone is stationary
RESEARCH APPROACH
Introduction

Research approach

Implementation

Results

Conclusion

Future work

Multiple drivers using crowdsensing.

One car drives along a highway and measures the acceleration.

Only the interesting events are shared.

The interesting events of multiple cars are grouped.

The groups are linked to a location.

Additional information from the location is used to combine information.

Which can be used to say something about the location.

3 distresses: 2.5 m/s^2

Max z acc: 2.3 m/s^2

Max z acc: 2.5 m/s^2

Max z acc: 2.8 m/s^2
IMPLEMENTATION
IN-CAR MOBILE CROWDSENSING

- Car
  - Smartphone
  - Sensor

- Road
  - Distress

- Location
- Causes movement
IN-CAR MOBILE CROWDSENSING - DESIRED SITUATION

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THE VIRTUAL SENSOR

Location = X,Y
Location = X',Y'

Road
Distress
Sensor

location
DATA CAPTURE

Data consists of:
- Timestamp
- Z acceleration
- X,Y,Z Quaternion
- Position

25 rides

68 rides
EVENT DETECTION

- Use $\sigma$ tolerance for detection
  - Detect events regardless of suspension
- $a\sigma$ based on manual validation
**EVENT DETECTION**

- **Event** = measurements outside $2.75\sigma$

![Graph showing two events with measurement points outside the standard deviation limits.](image-url)
EVENT DETECTION

- Look at measurements around events
EVENT DETECTION

- Merge events into one
VIRTUAL SENSOR CREATION

1

2

- Car A
- Car B
- Car C

- Center A
- Center B
- Center C
VIRTUAL SENSOR CREATION

3

Cluster

4

Cluster

Virtual sensor
CONNECT VIRTUAL SENSOR TO ASSET

- Road section (weggeg)
- Hectometer post (nwb)
CONNECT VIRTUAL SENSOR TO ASSET

Road section

- Virtual sensor
- Sensor azimuth
- Connected asset
CONNECT VIRTUAL SENSOR TO ASSET
RESULTS
PRECISION

- GPS precision events
  - Average distance to lane centreline: 3 m
  - Standard deviation: 2.4 m

- Transversal precision of virtual sensor

<table>
<thead>
<tr>
<th>Nr of rides</th>
<th>Nr of clusters</th>
<th>Average distance to lane centreline (m)</th>
<th>Standard deviation (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>27</td>
<td>1.54</td>
<td>0.96</td>
</tr>
<tr>
<td>20</td>
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<tr>
<td>30</td>
<td>32</td>
<td>0.82</td>
<td>0.66</td>
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</tbody>
</table>
ACCURACY
DATA FLOW

Rides: 108
Raw measurements: 4922596
Events: 12662
Virtual sensors: 526
Asset: 38
Hectometre posts: 221

Conversion rate: 96%
Invalid data points: 4729653
DATA FLOW


108 -> 4922596 -> 12662 -> 526 -> 38 -> 221

96%
MAPS
CONCLUSION
TO WHAT EXTENT CAN THE CURRENT STATE AND THE DEGRADATION OF A ROAD PAVEMENT ASSET BE MEASURED USING MOBILE CROWDSENSING?

Road pavement distresses are:

- Detected by using multiple indications
- Connected to assets
- Enriched with additional information
RESEARCH LIMITATIONS

- Average suspension for Dutch cars
- Smartphone location in car
- Hit direction of car on distress
FUTURE WORK
FUTURE WORK

Implementation

- Local analysis
- App adoption by users
- Cars as sensors

Academic

- Average Dutch car
- Relationship suspension - speed - distress size - car weight
- Low level info -> high level info
THANK YOU FOR YOUR ATTENTION
EVENT DETECTION

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DATA FLOW