Bicycle Travel Speed at Varying Gradients
Results based on registrations with Bluetooth and WiFi Sensors

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Content

• Background
• Equipment
• Test of equipment
• Results
• Conclusions
Why bicycle travel speed?

- Traffic models – Choice of transportation mode
- Planning of bicycle paths / Bicycle expressway
- Agreement on traffic growth in cities
Bluetooth vs AutoPASS - Number of travel times

08:00-08:05

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Bluetooth vs AutoPASS - Number of travel times

07:50-07:55

Chromatic bar chart showing travel times for Bluetooth and AutoPASS between 07:50-07:55.
Detection rate

Trondheim
- AutoPASS 80%
- Bluetooth 25-60%
  - BLIP Track better than other

Oslo
- AutoPASS 60%
- Bluetooth 25% (AADI)

Copenhagen (info from BLIP)
- BLIP Track 27%
Test in Oslo 2012 - Travel Time

AutoPASS – Mode based
Bluetooth – Mode based
Bluetooth – AADI (TrafficNow)
Test with 9 units in the same vehicle

- Sensor did not detect every unit
- 0-8 seconds between time stamps
Conclusions – Vehicle travel time

• Bluetooth has less detection rate than AutoPASS, but still enough for travel time information on main roads

• Some Bluetooth sensors are better than others (1.5-4 times higher detection rate)

• BLIP sensors best in our tests

• Filtering algorithms important!
Bicycle Travel Time

- Bluetooth and WiFi
- Test of technology and correlation between geometry and speed
Research Questions

1. Will the use of Bluetooth and WiFi sensors provide reliable travel time data from bicyclists?

2. How are bicycle section speeds affected by different gradients?
Answering Research Question 1

- A two-step test was performed to study the penetration rate and the accuracy of the registered travel time
  - Controlled test
  - Open test

- Equipment with both Bluetooth and WiFi sensors was investigated

- Two sets of sensors were placed with a distance of 550 meters between them
Controlled Test

• Test cyclists travelled back and forth a test section 25 times during nighttime, bringing a variety of mobile Bluetooth and/or WiFi enabled units (mobile phone, camera, remote control, portable sound speaker, PC mouse)

• The WiFi sensor detected 38,1% of the passing units, while the Bluetooth sensor detected 73,5%

• The next slide shows that the highest deviations from manual registrations were found among the WiFi registrations, measuring somewhat higher travel times. However, none significant differences between manual and sensor registrations were found
Controlled Test

Travel time per trip

Detected unit trips sorted according to travel time

Travel time [s]

Manual registrations
Bluetooth
WiFi
Controlled Test – Deviation Time Stamp

The diagram shows the deviation time stamp for WiFi and Blåtann. The x-axis represents time stamps ranging from -35 to 34, and the y-axis represents the number of recordings. The graph illustrates the distribution of deviation times for each technology.
Open Test

- Performed in real traffic during peak hours
- Passing cyclists (N=499) and pedestrians (N=177) were manually registered
- Filtering routines were used to separate pedestrians from cyclists
- Penetration rates of 19.5% for cyclists and 33.8% for pedestrians
- No significant differences between manual and sensor registrations
- A closer look into the deviations between manually and sensor registrations by dividing registrations into time intervals revealed that the deviations seem to stabilize below 5% when number of observations exceeds 20 (Next slide)
Open Test
Conclusions Tests

- Despite a penetration rate of 20%, reliable speed data is registered by WiFi and Bluetooth sensors, given a minimum of 20 observations.

- It is essential to provide good filtering routines to avoid inclusion of pedestrians and motorists in the dataset.
Answering Research Question 2

- Speed data was collected at seven road sections at varying gradients by use of Bluetooth and WiFi sensor equipment

- All registrations were accomplished on weekdays during the spring, covering a minimum of 24 continuous hours
### The Data Set

<table>
<thead>
<tr>
<th>Section</th>
<th>Length (m)</th>
<th>Gradient (%)</th>
<th>Uphill Registrations</th>
<th>Speeds (km/h)</th>
<th>Downhill Registrations</th>
<th>Speeds (km/h)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>N</td>
<td>% BT</td>
<td>Mean</td>
<td>Median</td>
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<td>310</td>
<td>16</td>
<td>15.7</td>
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<tr>
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<td>470</td>
<td>5.4</td>
<td>269</td>
<td>9</td>
<td>12.8</td>
<td>13.8</td>
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<td>460</td>
<td>9.2</td>
<td>75</td>
<td>15</td>
<td>8.6</td>
<td>8.6</td>
</tr>
</tbody>
</table>
Test sections
Answering Research Question 2

- Speed data was collected at seven road sections at varying gradients by use of Bluetooth and WiFi sensor equipment.

- All registrations were accomplished on weekdays during the spring, covering a minimum of 24 continuous hours.
Bicycle Travel Time – Uphill speed
Bicycle Travel Time – Uphill speed

Cumulative bicycle speeds uphill

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Bicycle Travel Time – Downhill speed

Hastigheter - Gj. verdier og 25 % og 75 % kvantiler
Negativ stigning (nedover)

- Gj. Hastighet
- Nedre filtr. verdi
- Øvre filtr. verdi

Stigningsgrad nedover

50 km/t
45 km/t
40 km/t
35 km/t
30 km/t
25 km/t
20 km/t
15 km/t
10 km/t
5 km/t
0 km/t

0,0 %
2,0 %
4,0 %
6,0 %
8,0 %
10,0 %
Bicycle Travel Time – Downhill speed

Cumulative bicycle speeds downhill

- 0.5
- 0.8
- 2
- 2.6
- 3.2
- 5.4
- 9.2
Conclusions

• At gradients close to zero, the mean speed is found to be 21-23 km/h
• The speed decreases by increasing gradient uphill, as do standard deviation
• Downhill, the findings suggest that there exists a threshold gradient. Speeds increase with increasing gradient downhill until this threshold reaches
• The road sections included in this study did not allow an exact identification of this threshold value. Thus, future studies should include more sections in the interval between 3.2% and 9.2% in order to identify the threshold gradient at which the mean downhill speed reaches its maximum
Thank you for Your attention!

Questions?

You can also contact me:
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