Energy Efficient routing with OSM

- reach your destination fast AND eco -

SOTM 2018 – Milan – 30.7.2018
- Dr. Arndt Brenschede -
B(ike?)Router?

- 01 / 2013 Initial release „BRouter“
- ....
- 01 / 2014 first, experimental car routing
- ....
- 05 / 2016 turning instructions
- 12 / 2016 turn restrictions
- 09 / 2017 kinematic model
- 10 / 2017 Map-QA road network

Usable car routing
Status Quo

- Market is dominated by motorway-centric routing, optimizing travel-time only
- Example: Stuttgart → Luxemburg (Router: OSRM), **Northern suburb**

351 km  Time: 3h 26m
Status Quo

- Market is dominated by motorway-centric routing optimizing travel.
- Example: Stuttgart → Luxemburg (Router: OSRM), City center

313 km  Time: 3h 25m  (-38km, same travel time)
Cost-Function in Routing:

\[ Cost = Time \]
Cost-Function in Energy Efficient Routing:

\[ \text{Cost} = \text{Time} + \frac{\text{Energy}}{P_{\text{weight}}} \]

\[ P_{\text{weight}} = \text{Weighting Power (measured in kW)} \]
## Specify Energy Preference: 2 Options

<table>
<thead>
<tr>
<th>V-max (km/h)</th>
<th>P-weight (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>61</td>
<td>3,7</td>
</tr>
<tr>
<td>89</td>
<td>11</td>
</tr>
<tr>
<td>110</td>
<td>22</td>
</tr>
<tr>
<td>120</td>
<td>28,6</td>
</tr>
<tr>
<td>144</td>
<td>50</td>
</tr>
</tbody>
</table>
Equivalence of $P_{\text{weight}}$ und $v_{\text{max}}$!

$P_{\text{weight}} = 10 \text{kW}$

\[
\text{Cost} = \text{Time} + \frac{\text{Energy}}{P_{\text{weight}}}
\]
Equivalence of $P_{\text{weight}}$ and $v_{\text{max}}$!

Cost-Minimum

\[ P_{\text{weight}} = 10 \text{kW} \]

Cost = Time + \[ \frac{\text{Energy}}{P_{\text{weight}}} \]

\[ P_{\text{weight}} = c_w \cdot A \cdot \rho \cdot v_{\text{max}}^3 - P_{\text{aux}} \]
Equivalence of $P_{\text{weight}}$ und $v_{\text{max}}$!

Cost-Minimum

\[ P_{\text{weight}} = 10 \, \text{kW} \]

\[ \text{Cost} = \text{Time} + \frac{\text{Entropy}}{P_{\text{weight}}} \]

\[ P_{\text{weight}} = c_w \ast A \ast \rho \ast v_{\text{max}}^3 - P_{\text{aux}} \]
Routing depending on Energy-Preference

Aschaffenburg → Bensheim \( V_{\text{max}} = 160 \text{ km/h} \) \( \implies \) 52 Minutes, 23 kWh
Routing depending on Energy-Preference

Aschaffenburg → Bensheim \( V_{\text{max}} = 120 \text{ km/h} \) \( \Rightarrow \) 72 Minutes, 9 kWh
Routing depending on Energy-Preference

Aschaffenburg → Bensheim \( V_{\text{max}} = 60 \text{ km/h} \) \( \Rightarrow \) 83 Minutes, 6.5 kWh
Routing depending on Energy-Preference

Aschaffenburg → Bensheim $V_{\text{max}} = 60 \text{ km/h}$ ===> 83 Minutes, 6.5 kWh
Energy – Time Diagram

Energy consumption [kWh]

6 ==> 23 kWh = + 280 %

160 km/h
120 km/h
60 km/h

Travel Time [minutes]

Efficient
Energy – Time Diagram

- 160 km/h
- 120 km/h
- 60 km/h

Travel Time [minutes]

Energy consumption [kWh]
Energy – Time Diagram

- 160 km/h
- 120 km/h
- 60 km/h
Energy – Time Diagram

- 90 km/h
- 130 km/h
- 44% increase

Travel Time [minutes]

Energy consumption [kWh]
Energy – Time Diagram

Energy consumption [kWh]

Travel Time [minutes]

130 km/h

90 km/h

+ 180 %
Should I ? Really ?
- travelling on minor roads needs high quality maps -
2 Errors in 640 sqkm

==> ca. 1000 Errors

in Germany

( 357,000 qkm )
QA Road-Network: Suspect Scanner / Manager

<table>
<thead>
<tr>
<th>Datei</th>
<th>Bearbeiten</th>
<th>Ansicht</th>
<th>Chronik</th>
<th>Lesezeichen</th>
<th>Extras</th>
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</table>

suspect list for germany
see watchlist
back to country list

current level: secondary

```
7.770091,51.654872
8.630739,49.866537
8.631033,49.866603
8.655798,49.991977
8.65709,49.991296
8.162019,50.84019
8.169072,50.844596
8.772501,50.807671
8.773487,50.807586
11.608742,48.117963
11.618093,52.109905
11.61994,52.110163
11.62006,52.109493
11.620073,52.109494
11.620571,52.109696
13.572893,51.210888
13.587674,51.2008
13.613796,51.288552
13.65406,51.001332
```

Open in BRouter-Web
Open in OpenStreetmap
Open in JOSM (via remote control)
mark false positive (=not an issue)
mark as a confirmed issue
back to issue list
QA Road-Network: Suspect Scanner / Manager
QA Road-Network: Suspect Scanner / Manager
Outlook / TODOs

- implement road network QA world-wide

- Update BRouter integration in popular MapTools:

<table>
<thead>
<tr>
<th>Name</th>
<th>Turning-Hints</th>
<th>Time of Arrival</th>
<th>Street-names</th>
<th>Direction-Hints</th>
<th>Lane-mapping</th>
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</thead>
<tbody>
<tr>
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<td>n.a</td>
<td>n.a</td>
</tr>
</tbody>
</table>

- … Integrated driving assistance for electric cars?
Thank you!

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