Exploration of fog detection and visibility estimation from camera images

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Introduction

• Fog is a local phenomenon and cannot adequately be determined with density of current meteorological network.

• Camera’s widely used for security, surveillance, traffic, construction, tourism …, e.g. Dutch road authorities operate ~ 5000 camera’s.

• Images & processing software readily available.

• Large potential source for visibility information.

• Exploration considering fog detection and quantitative visibility estimation.
Landmark discrimination

- Similar approach as observer using landmarks at known distance
Landmark discrimination

- Objects are visible when sufficient edges in corresponding area
- Results are the same as by visual assessment of image
- No markers at large distance
- Often non-homogenous cases (shallow fog or fog patches)
Contrast reduction

- Visibility estimation from atmospheric contrast reduction

- Contrast definition used: $C_w(x) = \frac{I(x) - I_B}{I_B}$

- Koschmieder’s law: $C(x) = C_0 e^{-\sigma x}$

- Use 2 similarly dark objects at known $x_1$ and $x_2$

  $$\frac{C(x_2)}{C(x_1)} = e^{-\sigma (x_2 - x_1)}$$

- Select objects with care e.g. trees.

- Avoid reflections/shade

- limited to $x_1, x_2, \ldots x_i$ range
General image features

• Dark channel prior uses assumption: in most of the non-sky patches, at least one color channel has very low intensity at some pixels.

• Deviation due to haze

• Dehazing technique in image processing

\[ I(x) = t(x) \ J(x) + A \ [1-t(x)] \]

attenuation    airlight

• Transmission \((t)\) related to visibility

• Mean edges related to visibility
Fog classification decision tree

- Decision tree using general image features
- Dense fog: MOR < 250 m
- Training / evaluation set
- Fog cases 25 / 47
- POD 64 % / 100%
- FAR 16 % / 6 %
- Dusk / faulty MOR
Visibility estimation regression

- best linear fit to log(MOR) of training set was obtained for

$$13.3 + 282 \times \text{meanEdge} - 0.02 \times \text{changePoint} - 479 \times \text{meanBrightness}$$

<table>
<thead>
<tr>
<th></th>
<th>&lt; 250 m</th>
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<th>&lt; 1000 m</th>
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<tbody>
<tr>
<td>POD (%)</td>
<td>Training</td>
<td>Evaluation</td>
<td>Training</td>
<td>Evaluation</td>
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<tr>
<td>89</td>
<td>98</td>
<td>88</td>
<td>89</td>
<td></td>
</tr>
<tr>
<td>FAR (%)</td>
<td>0</td>
<td>18</td>
<td>13</td>
<td>30</td>
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<tr>
<td>Hits (#)</td>
<td>16</td>
<td>46</td>
<td>28</td>
<td>81</td>
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![Model plot](image)
Conclusions

• Work in progress, further extensions / optimizations ongoing.

• Expansion of images and reference MOR data.

• Sensitivity and robustness of the method to location / image scenery and camera settings and image quality can be investigated.

• The results presented here look promising and justify further study.

• Visibility information from camera images can be used for validation.

• Awareness tool for forecasters, for example showing colour coded results of presence of fog on a map...