An Approach for Evaluating Robustness of Edge Operators using Real-World Driving Scenes

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Outline and Objective

The Edge Operators
The compared edge operators are:
- Sobel (gradient edge operator).
- Canny (thresholding gradient edge operator).
- Kovesi-Owens (Fourier phase-based operator).

The Process Outline
Noise-Free Original Image
Noise-Free Edge Image
Binarised Noise-Free Edge Image

Noise-Added Original Image
Noise-Added Edge Image
Binarised Noise-Added Edge Image

The calculated metrics are:
- Symmetric correctness $C$
- Symmetric false positive $E^+$
- Symmetric false negative $E^-

$C = \frac{|A \cap B|}{|A \cup B|} \times 100%$
$E^+ = \frac{|B| - |A \cap B|}{|A \cup B|} \times 100%$
$E^- = \frac{|A| - |A \cap B|}{|A \cup B|} \times 100%$

Subjective Evaluation
The criteria is how well the operators manage to detect distant vehicles, road signs and lanes. This shows how robust the algorithms work between the original images and noise added images.

Numerical Evaluation
We generated binarised images of both original and noisy images using AboTaleb’s higher-order entropy algorithms.

Set $A \subseteq \Omega$ ($\Omega$ is the image domain) points identified by the ground truth binarised edge image.

Set $B \subseteq \Omega$ ($\Omega$ is the image domain) points identified by the ground truth binarised noise added edge image.

Results

<table>
<thead>
<tr>
<th>No.</th>
<th>Image</th>
<th>% Correct $C$</th>
<th>% False Neg. $E^-$</th>
<th>% False Pos. $E^+$</th>
<th>Total SNR$^T$</th>
<th>False Pos. SNR$^+$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Const. Site</td>
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<td>83</td>
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<td>23</td>
<td>64</td>
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<tr>
<td>2</td>
<td>Safe Turn</td>
<td>87</td>
<td>79</td>
<td>12</td>
<td>18</td>
<td>62</td>
</tr>
<tr>
<td>3</td>
<td>Dusk Light</td>
<td>83</td>
<td>75</td>
<td>15</td>
<td>24</td>
<td>72</td>
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<tr>
<td>4</td>
<td>ALL</td>
<td>80</td>
<td>72</td>
<td>15</td>
<td>28</td>
<td>72</td>
</tr>
</tbody>
</table>

The high False Pos. SNR for Kovesi-Owens indicates a higher robustness to noise.

Dancing-light image, example of the binarised edge images. Binarised noise-free edge image (left) and binarised noise-added edge image (right).

Construction-site images. Left figure is the original image; right figure is the noise-added image. Kovesi-Owens appears to have better structure in both the noise-free and noise-added images. This high-lights the robustness to noise.