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Tracking computer mouse movement for studying visual information processing: applications to driving situations in reduced visibility conditions

Boris Quétard, Jean-Charles Quinton, Michèle Colomb, Marie Izaute, Frédéric Bernardin, Giovanni Pezzulo, Racha Gana, Martial Mermillod

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Introduction

Driving is mostly a vision-based task involving complex cognitive processing so as to adapt the environment and conditions which may change rapidly. Within the context of the *LabEx IMobS3 / PEVMA* project, we study critical situations combining:

- *Reduced visibility* (night, fog, rain, glare)
- *Rich driving environments* (obstacles, road users, distractors)

Critical targets –like pedestrians– must be detected on time to avoid accidents, but may be hardly visible in degraded conditions. Solutions for mobility in the future, including driver assistance and autonomous systems, must be robust to such conditions.

Experimental context

We aim at combining psychophysical experiments and computational developments to evaluate and model how humans deal with uncertainty in visual information, manipulating both:

- *Saliency* of the stimuli (reactive bottom-up information)
- *Driving context* (predictive top-down influences)

We then record dynamical measures of the subjects behavior:

- *Eye movements* (reflecting information gathering strategies)
- *Hand movements* (reflecting dynamical decision-making)

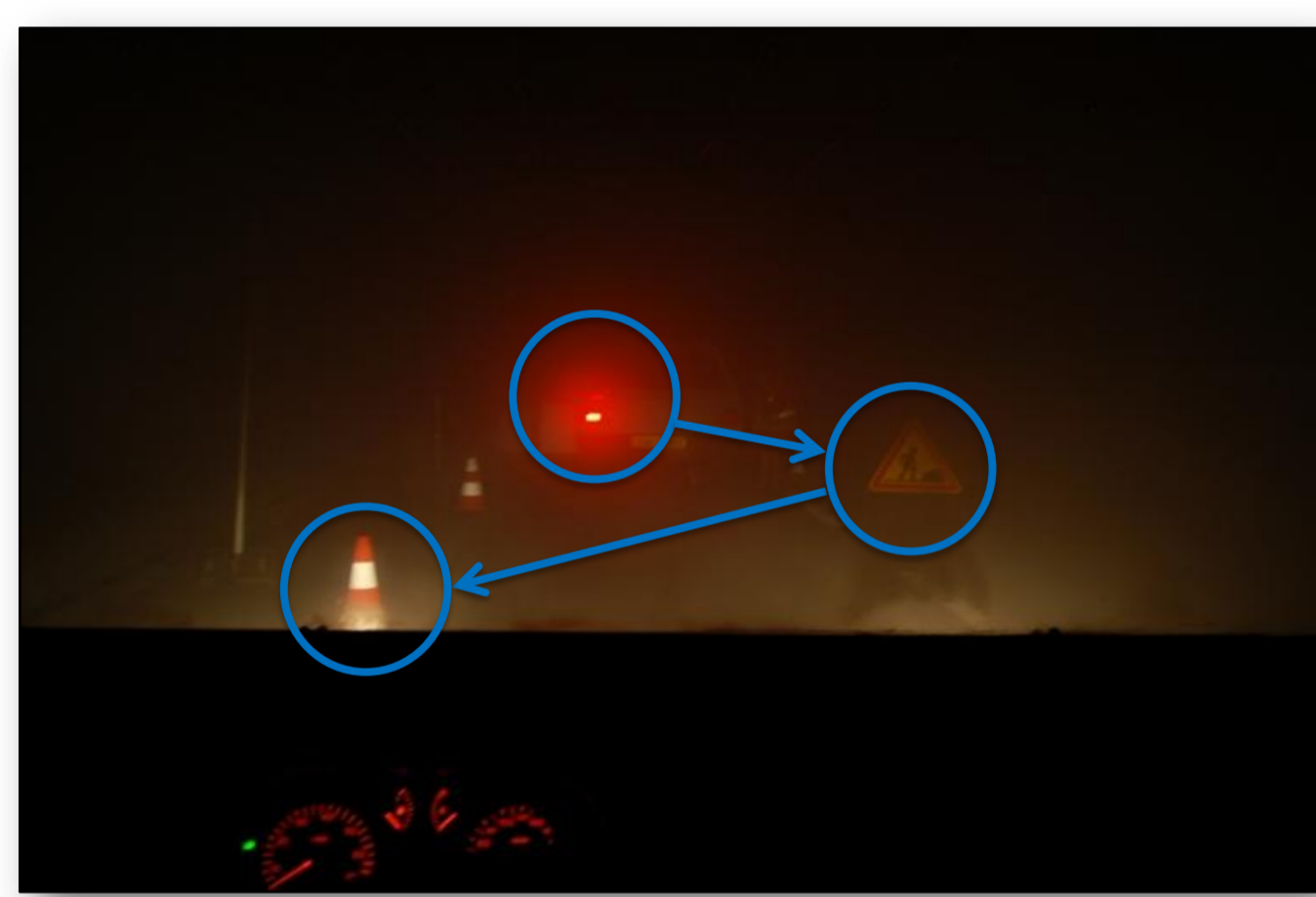


Illustration of stimuli and scanpaths (EyeTracking)

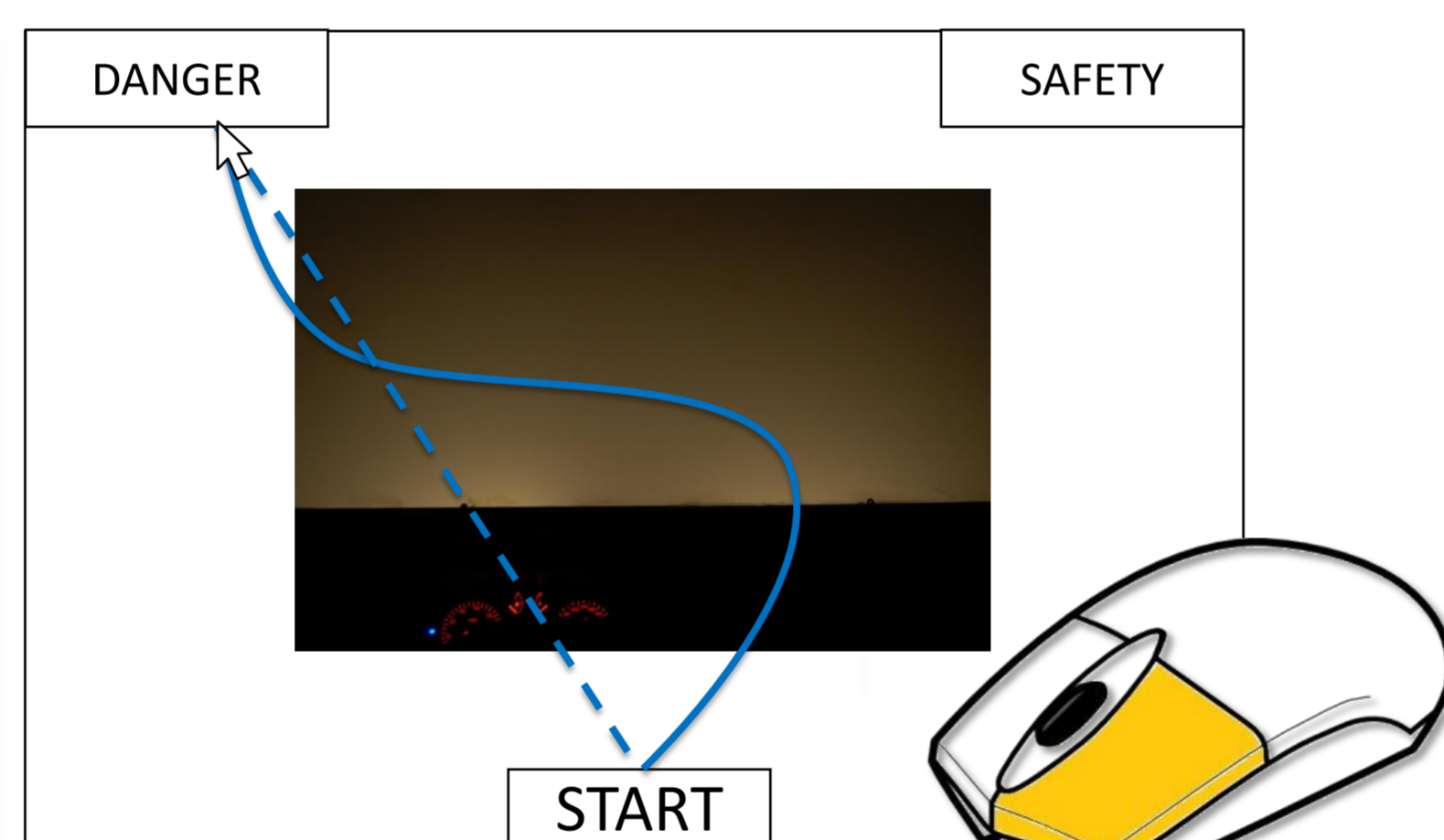


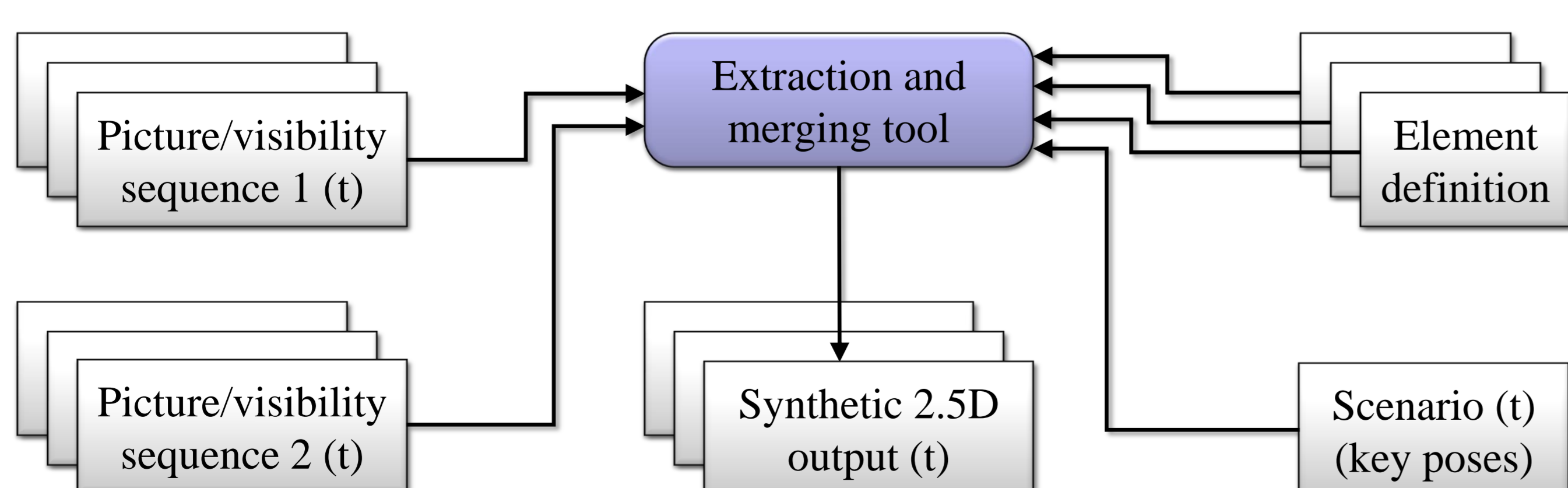
Illustration of dynamic decision-making (MouseTracking [1])

Picture database

The *CEREMA* in Clermont-Ferrand can generate fog in an up to 30m long tunnel, where various driving situations can be reproduced [2]. The density of fog can be precisely controlled and the associated visibility measured by a transmissometer.

Because of time and experimental constraints, we may want to generate synthetic pictures from real images captured in the fog by applying the following procedure:

- *Capture real pictures and record visibility* (synchronously)
- *Design static/dynamic scenarios* (e.g. with a 3D CAD software)
- For any image in the sequence to generate
 - *Extract elements* from adequate pictures (fog level, position...)
 - *Merge and adapt* these elements (resize, normalize and blend)
 - *Save* the resulting 2.5D synthetic image



Data flow diagram of the 2.5D synthetic image generation

Saliency maps

Saliency maps are the output of neuro-inspired algorithms developed to mimic the way humans extract information from their visual environment. We here limit ourselves to the bottom-up version originally introduced in [3], extracting multi-scale luminance and color contrasts, as well as oriented contours from input images. The objectives of applying such algorithm are:

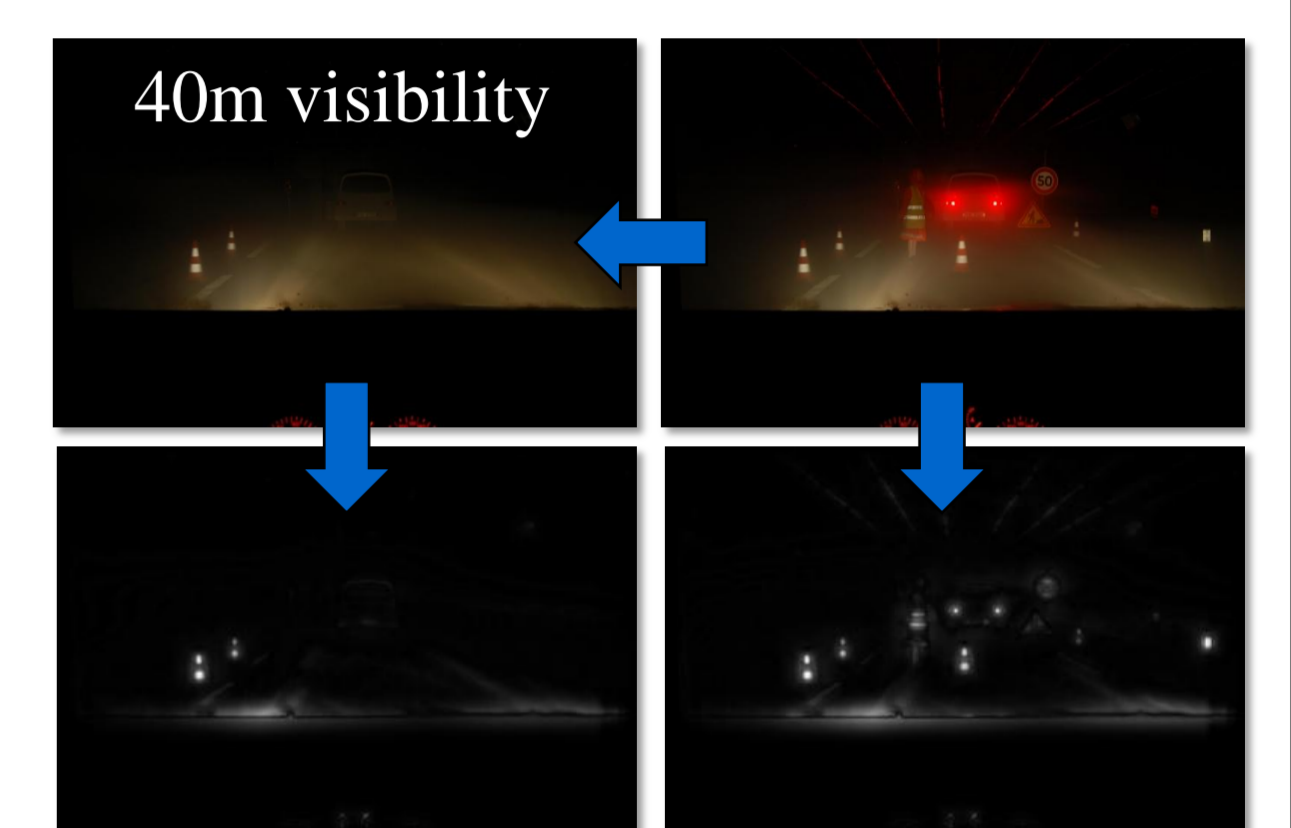
- *Applicability of saliency* for night / fog images
- *Modeling and analysis of scanpaths* (eye tracker)
- *Control of biases* in visual attention
- *Ecological validity of 2.5D images*

Results

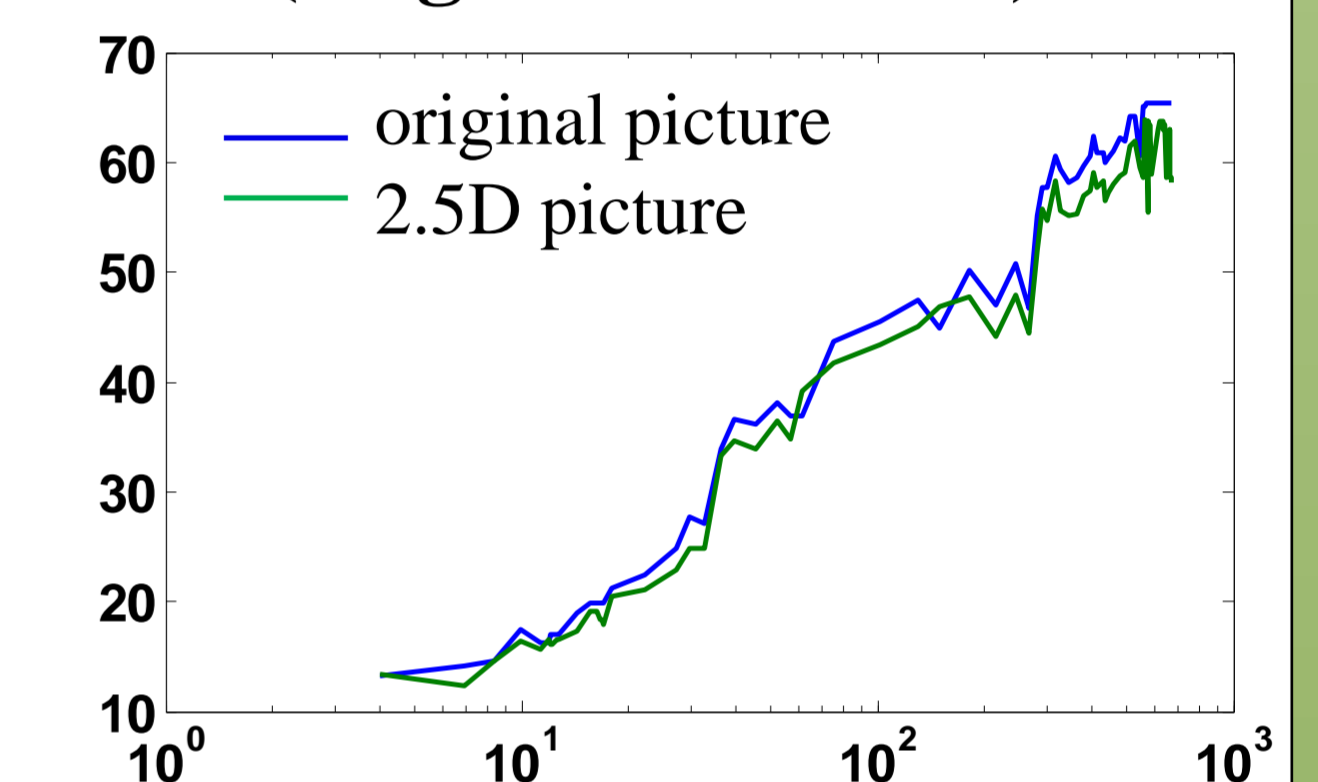
Following the analysis of saliency maps on the original and generated pictures, the following results have been obtained:

- Intensity chain* (luminance contrasts) gives the stronger response (visibility <100m) in night and fog conditions.
- Exponential attenuation of light* through a scattering atmosphere is reflected by the maximal saliency.
- Consistent results* ($\Delta < 2\%$ for original vs 2.5D picture) are obtained, despite the broad visibility range and basic merging method used.

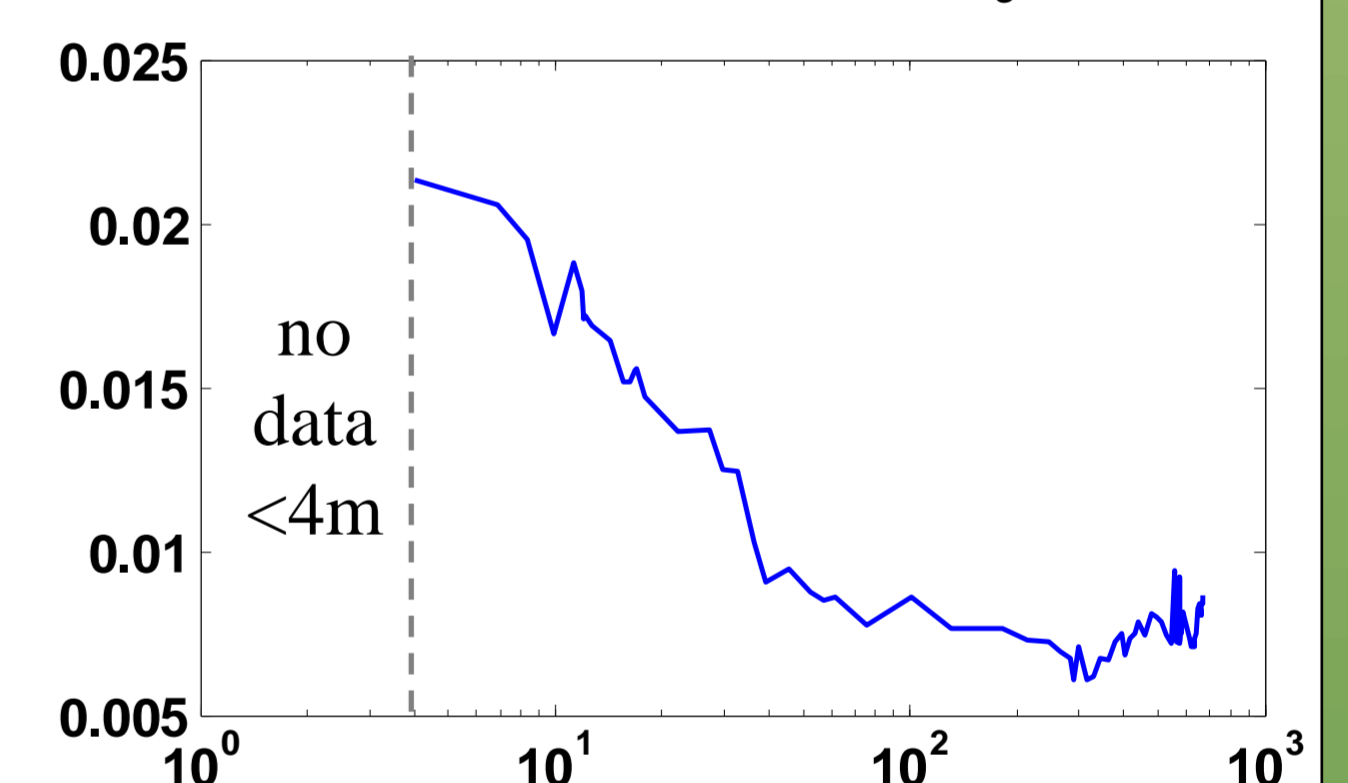
The high variability for some high visibility values may reflect the presence of eddies on the transmissometer path.



A. Saliency from pictures (original and 2.5D)



B. Maximal saliency function of visibility (m)



C. Mean saliency difference function of visibility (m)

Conclusion

The database and methodology are yet to be validated by psychology experiments, but multi-scale intensity-based *saliency algorithms seem to consistently and efficiently extract information from fog pictures*.

Because the presence of fog simplifies the algorithmic merging process, *2.5D synthetic images reflect identical properties* as their real camera counterparts. However, objects must be clearly separated and reciprocal illumination limited in the original images to avoid discrepancies in the output pictures. Better algorithms and segmentation methods should thus be implemented to improve the results and their ecological validity.

Main references

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- Cavallo, V., Colomb, M. & Doré, J. (2001), "Distance perception of rear lights in fog", *Human Factors*, vol. 43:3, 442-45.
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