Onboard Measurement of the Atmospheric Visibility: Static Calibration and Quantitative Evaluation

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Abstract

Perception sensors (cameras, laser, radar…) are being introduced into certain vehicles. These sensors have been designed to operate within a wide range of situations and conditions (weather, luminosity, etc.) with a prescribed set of variation thresholds. Effectively detecting when a given operating threshold has been surpassed constitutes a key parameter in the creation of driving assistance systems that meet required reliability levels. With this context in mind, an atmospheric visibility measurement system may be capable of quantifying the most common operating range of onboard exteroceptive sensors. Such information comes handy to adapt the way the sensors are operated, and the way the data they record is processed, or to warn the driver that the onboard assistance system is momentarily inoperative. Moreover, a system capable of either detecting the presence of fog or estimating visibility distances constitutes in itself a driving aid, because people actually tend to overestimate headway distances in foggy weather [1], and to drive at inappropriate speeds.

In the framework of the French project ARCOS [2], we have developed such a system using onboard CCD cameras, devoted to the first type of the previously mentioned applications . This system is broken up into three modules. The first module uses the “v-disparity” representation [3] to detect obstacles which occlude part of the road and the traffic. The second module estimates the distance of the most distant visible picture element belonging to the road surface in the current image. It combines a depth map of the environment ahead of the vehicle, obtained by stereovision, and computed local contrasts above a certain threshold, so as to estimate what we call the “mobilized visibility distance”, like on Fig. 1a. This distance ought to be compared to the “mobilizable visibility distance”, which is the greatest distance at which a potential picture element on the road surface would be visible. We have shown that the “mobilizable visibility distance” is very close to the meteorological visibility [4], if the threshold contrast for an object to be visible is set to 5 %. And as a matter of fact, the third module detects daytime fog and estimates the meteorological visibility [5], like on Fig. 1b, thanks to a successful instantiation of Koschmieder’s law [6] which allows to compute fog extinction coefficient.

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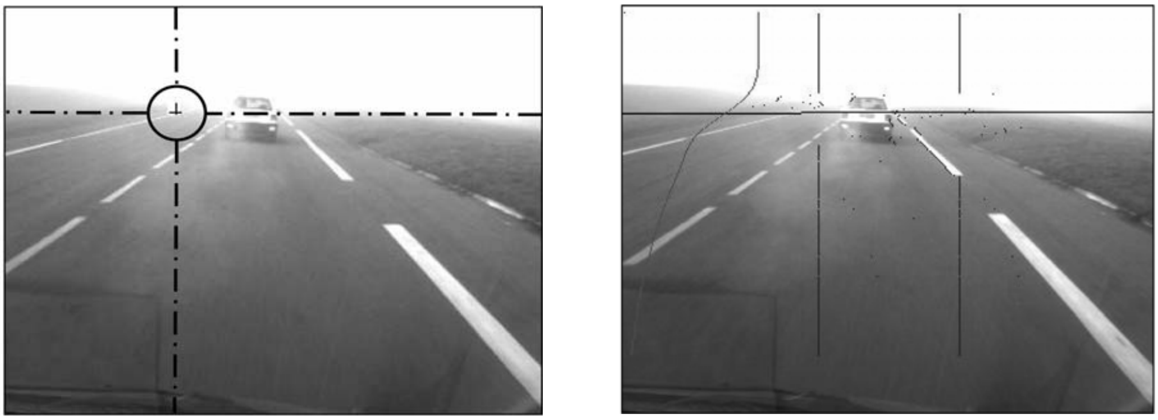
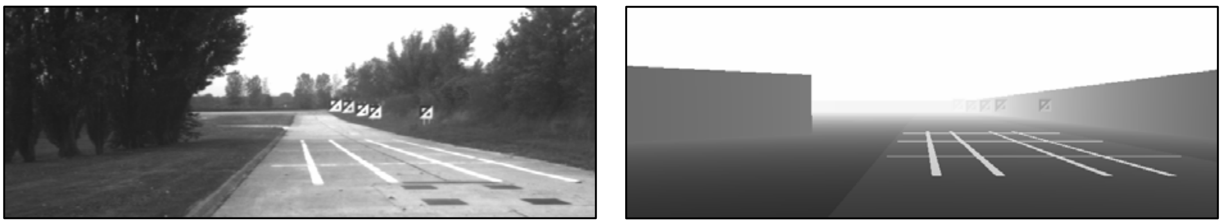


(a) (b)

Figure 1: (a) Example of mobilized visibility measurement represented by the black cross on the white window. (b) Example of meteorological visibility measurement represented by the horizontal black line.

So far, these methods have only been evaluated qualitatively, through a subjective analysis of the mean and standard deviation of the measures in the cases of different rides in poor visibility conditions. Quantitative assessment has not been endeavoured yet, due to the lack of a reference visibility sensor.

Recently, we have equipped our test track in Versailles (France) with five large specific targets, located between 65m and 200m from the cameras onboard the stationed vehicle. The idea is to take pictures of these targets in adverse visibility conditions and to estimate the extinction coefficient of the atmosphere based on the attenuation of their contrast. This static measurement, which uses reference targets, can then be compared to the results of our onboard dynamic techniques, which require no reference.



(a) (b)

Figure 2: (a) Actual picture of our dedicated site with the five large targets under sunny conditions. (b) Photometrical simulation of the site under foggy weather (V_{met} = 200m).

In our paper, we will first present Koschmieder's model and deal with the definitions of the different visibility distances we used in our measurement framework, as well as the links which exist between them. Then, our two specific onboard techniques to estimate visibility distance will be briefly described and compared to the few other existing techniques. In a third section, we will present our dedicated site and how we use it to calibrate and to evaluate the previous techniques. Finally, we will give the first results of a quantitative evaluation of our onboard techniques, using actual pictures or photometrical simulations [7] of the calibration site in foggy conditions. The results will be discussed and perspectives will be given.

References

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