Repeatable Visibility Degradation using Water Spray for AD and ADAS Testing

Automated vehicles and sensor-based safety functions have been identified by the automotive industry as catalysts for improved safety, sustainability, accessibility, and efficiency. To accelerate AD and ADAS-systems research, this work outlines the main challenges in developing and evaluating a test method for generating road spray, a turbulent mix of fine water particles that reduce visibility caused by vehicles driving on wet surfaces.

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The automotive industry sees automated vehicles and sensor-based safety as key to safety and efficiency. As the need for robustness and availability increases, so does the need for repeatable test methods in adverse weather conditions. This study developed a method for testing road spray created by wet road surfaces and an automated tool for evaluation of data. Key challenges included minimizing light and wind disturbances, while achieving up to 80% visibility reduction with ±5-15% repeatability.

The AstaZero Spray Rig

The AstaZero Spray Rig is a mobile trailer with a steel frame and tarpaulin cover for easy access, enabling dynamic testing by towing it in front of sensors. It includes a 250-liter tank with a 200-bar Alcon pressure washer. The water system features quick-release outlets for flexibility, with a precision valve and manometer for flow adjustment. Nozzles, mainly from Ultra Fog and PNR, are mounted on adjustable RAM Mounts and used to replicate natural spray droplets. Future upgrades may add electronic controls.

The AstaZero spray rig with a contrast board as the sensor target.

Evaluation

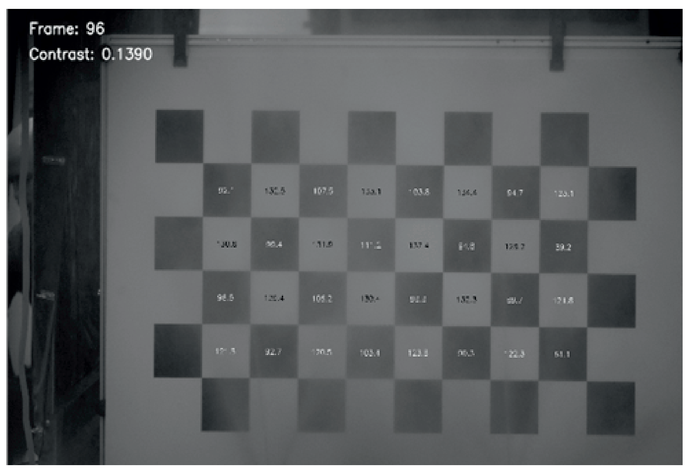
Our setup consists of several steps:

- Select the test location
- Rig a sensor and aim it at a target
- Calibrate the sensor
- Start capturing sensor data
- Generate spray using the AstaZero Spray Rig
- Stop capturing sensor data and analyze logs.

The components of our method are: a sensor, a target, and the medium between them, which allows us to assess factors that influence sensor performance through the medium.

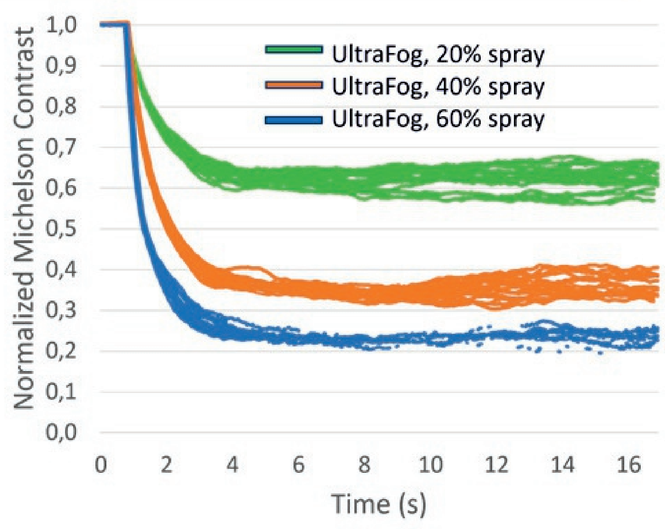
This work quantified visibility using contrast, an objective measure. Comparing contrast with and without spray gives a contrast attenuation value, indicating reduced visibility. Similar metrics are used in other studies, while light extinction, though not used here, is considered for future research.

Specifically, Michelson contrast was chosen to study the effect of uniform road spray on perceived contrast. Other methods compare adjacent squares on a target but were unsuitable for this study, as they unevenly weight squares based on their position.



A video frame, with the michelson contrast value calculated in the top left by the analysis tool.

We automated data analysis using our open-source Python tool with OpenCV. The tool detects a checkered pattern in video frames, calculates the average Michelson contrast from the black-and-white regions, and stores the mean contrast values in a CSV file.



All indoor experiment runs, used to prove the repetability of the method.

Results

Experiments were done both outdoors and indoors to determine a baseline environment. Compared to the corresponding data collected outdoors, the indoor results have less spread, indicating that the spray created from the AstaZero Spray Rig is repeatable with fair accuracy when operated indoors. Moreover, the spread is lowest for each nozzle setting between 4 and 8 seconds into the experiment, and the contrast for a specific nozzle spray setting remains within a ±0.5-0.15 contrast interval. The table below shows average contrast, standard deviation, max and min values, and contrast spread for UltraFog spray settings of 20%, 40%, and 60%. Each setting has 5520 data points over the first 5-16 seconds. The spray levels are based on adjustment knob settings, not actual water output, which may explain the non-linear contrast attenuation.

		Avg 5-16s	Stddev	Max	Min	Spread
Indoor	20% spray	0,625	0,025	0,678	0,561	0,117
	40% spray	0,352	0,020	0,411	0,303	0,109
	60% spray	0,233	0,012	0,274	0,195	0,079
Outdoor	20% spray	0,888	0,067	0,991	0,634	0,357
	40% spray	0,646	0,130	0,978	0,390	0,587
	60% spray	0,399	0,116	0,798	0,227	0,571

Summary of all experimental results

FACTS

- Flow and pressure control
- 50-400 µm droplet sizes
- Up to 100% contrast attenuation
- Automated contrast evaluation

Contrast Attenuation (CA) adjustable from none to near 100% is possible. Pictures showing around 0, 20 and 70% CA

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