PROJECT TITLE : ROBUST OBJECT DETECTION IN ADVERSE WEATHER CONDITIONS FOR AUTONOMUS VEHICLES

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1. Problem Statement

The vision systems of autonomous cars must identify and detect oncoming objects such as pedestrians, other traffic, traffic lights, and other hurdles along their path to ensure safe passage. However, the most adverse weather conditions, like fog, rain, snow, and poor lighting, highly impair their operations and give rise to serious legitimate safety concerns. Additional effects caused by noise due to weather, such as rain streaks and snowflakes, low visibility, and lens interferences, obscure critical features necessary for object detection and make safety and reliability even more challenging.

It deals with addressing the challenge of reduced accuracy in object detection during bad weather conditions. A robust object detection model would perform with utmost accuracy in challenging weather scenarios to ensure safety in the operation of autonomous vehicles.

2. Proposed Solutions

a. Multi-Sensor Fusion Approach

The core of this solution will involve sensor fusion, one sensor fusion technique that combines data from multiple sensors: cameras, radar, and LIDAR. This will mitigate the disadvantages brought forth when using a single sensor in trying to detect objects with higher accuracy under most weather conditions.

b. Image Quality Enhancement via Neural Networks

We realize real-time filtering and de-blurring using deep neural networks to enhance the quality of input images in conditions where visibility is low. We pre-process the image for better object detection performance by removing weather-induced noise using networks optimized for de-hazing, de-raining, and de-snowing.

c. Dynamic Model Re-Training

In that respect, we will use a dynamic approach of retraining to have better robustness on edge cases. This means new weather patterns encountered ensure that, in the real world, the model is continuously adapting to whatever data it's being subjected to by retraining. This continuous learning loop will make sure that the model evolves to handle such rare and complex weather scenarios effectively.

3. Data and Recourses

a. Datasets

BDD100K: A large-scale dataset with diverse driving conditions, including adverse weather scenarios such as fog, rain, and snow. This dataset provides the foundation for object detection tasks with robust annotations for vehicles, pedestrians, traffic signs. We will use this as our training dataset, here is the link (https://www.kaggle.com/datasets/solesensei/solesensei_bdd100k).

b. Tools and Technologies

- Neural Networks for filtering and de-blurring techniques, leveraging state-of-the-art architectures like FFA-Net for image enhancement.
- Multi-Sensor Fusion Techniques to merge data from cameras, radar, and LIDAR for improved accuracy in low-visibility conditions

4. Evaluation Metrics

a. Mean Average Precision

Measuring the accuracy of object detection in diverse weather conditions.

b. Precision and Recall

Assessing the correctness and completeness of the model's object detection.

c. Frame Per Second

Ensuring the system performs in real-time, suitable for autonomous vehicle applications.

d. Robustness under Adverse Conditions

Testing the model’s ability to maintain high detection accuracy in extreme weather scenarios like fog, rain, and snow.

5. Potential Impact

Therefore, the project promises major enhancement in the safety and reliability of AVs under bad-weather conditions. With such improvement in the robustness of object detection systems, the likelihood of accidents due to poor visibility and sensor failure will be reduced. It will also contribute to the general area of autonomous driving by providing additional methods of dealing with challenging environmental conditions.

6. Published Paper

https://openaccess.thecvf.com/content/WACV2024/papers/Gupta_Robust_Object_Detection_in_Challenging_Weather_Conditions_WACV_2024_paper.pdf