Vehicle Detection in Foggy Conditions

Rahul Banavathu (2006028)
Modem Veda Sree (2006032)
Bollina Kavya Sri(2006085)

B.Tech(CSE)-⟨Semester 7⟩

Under the supervision of
Dr. Suddhasil De

Department of Computer Science and Engineering
National Institute of Technology Patna

October 2023

Outline

Introduction

- Self-driving vehicles are going revolutionary in the field of computer science as well as automobile science.
- But it becomes a significant challenge when the weather conditions are not ideal, e.g., foggy conditions. Which requires technological advancement in order to function accordingly.
- Despite the availability of several robust solutions online, it becomes quite an issue in terms of accuracy while being constrained over speed.
- The idea of this project is to develop a solution that tackles the above mentioned problems using state-of-the-art methods available online. Of which, the one we opted is, Faster-RCNN architecture powered with the PyTorch Framework that is being trained with a dataset that contains adverse possibilites to train the model in such a way to tackle a wide range of issues.
- Our current objective is to improve the accuracy with the least possible computational complexity.

Summary of Related Works

- R-CNN [4] (Region based Convolutional Neural Network)
  - R-CNN uses an external region proposal algorithm to generate region proposals.
  - It consists of an external backbone for feature extraction and an object detection head.
  - The extracted features are then fed into a classifier to determine the presence of objects in each region.
- Domain Adaptation [2]
  - Labeled data from the target domain is being collected which is similar to the real world data.
  - The backbone of the faster R-CNN will be trained on the target domain data to adapt to specific features and patterns.
  - On the other hand, the Region Proposal Network (RPN) generates regions that are crucial to the target domain, making it more accurate.

Motivation

- Need of accuracy despite speed constraints. (from Table 1):
  - Accuracy
    - Accuracy of this model will be significantly promising and the speed can be improvised.
  - Two-staged detection
    - The concept of domain adaptation focuses the model towards the detection requirement.
    - The domain specific regions are crucially treated, which discards the unwanted regions and saves time.

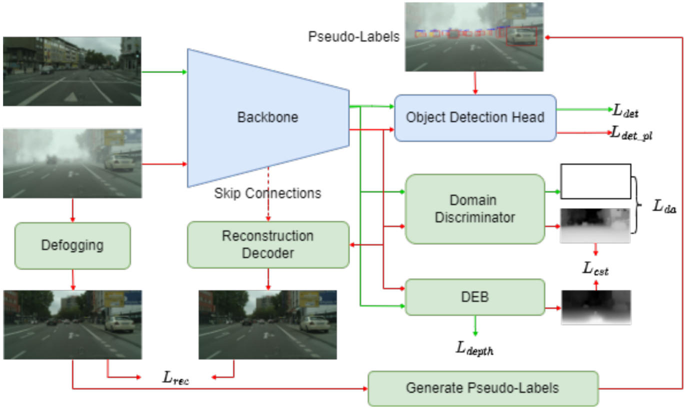
Problem Statement

- Vehicle Detection under foggy conditions.
- The underlying system environment characteristics include:
  - Reduced visibility in foggy images.
  - Complex atmospheric conditions caused by haze, fog, and smoke
  - Variability in the density of fog.
- In order to:
  - Surpass other Faster R-CNN models in terms of accuracy.
  - Reduction in the running time of foggy image detection algorithms for real-time applications.
  - To prioritize accuracy over speed.

System Model

- Our model is an vehicle-detection system that can detect multiple and different kinds of vehicles under foggy weather conditions that are present in an image or a video.
- The model features two-stage domain specific detection which fine tunes the detection and predicts class probabilities for each kind of object.
- This model can be trained with specific foggy datasets, that consists of images with annotations that are captured in various adverse foggy conditions which enables the model to determine specific features that are posed by foggy environments.
- In our evaluation of the model as dual-stage object detection model, we concentrate on the accuracy and various classes of objects detected by the model.

Pictorial Representation



Architecture of Our Model (contd.)

System Model

- The architecture of this model is convolutional neural network based that consists of two major components:
  - Backbone Network
  - Head Network
- Backbone extracts feature maps from the input images.
- Object detection head localizes and categorizes object instances from the feature maps.
- Domain discriminator and Depth Estimation Block (DEB) encourage the backbone to extract fog-invariant features, and maintains depth distributions.
- Reconstruction decoder minimizes the fake object features generated by Domain Adaptation (DA).
- Pseudo-Labels involve target domain information in the pipeline, and apply consistency regularization between fog and defogged images.

Architecture of Our Model (contd.)

Why this model is better than other models?

- Our model is trained with a vast range of input data, which contributes to significant learning and more accurate detection.
- A two-stage detection model along with domain adaptation improves the detection accuracy significantly with the cost of some extra time.
- So, this model is majorly concentrated towards accuracy which includes different kinds of vehicles and detection of people too.
- Training under various conditions and adverse scenarios ensures the enhancement of accuracy of the generated results.

Theoritical Comparison with related works

Table 1: Characteristics Comparison of Related works

Reference	Method	Number of Stages	DeFog	Image Quality Reduction
Yang X (2022) [2]	Faster R-CNN + DA	Two Stage	YES	NO
Farhodov (2019) [4]	OpenCV + Faster R-CNN	Two Stage	YES	YES
Chin (2018) [5]	Faster R-CNN	Two Stage	NO	NO

Simulation/Tentative TestBed Environment

- Experiment: Vehicle detection under foggy conditions.
- Description: This experiment involves training and testing our algorithm for vehicle detection under foggy weather conditions.
- Hardware:
  - CPU: AMD Ryzen 5 4600H - 6C/12T base 3GHz and max. 4GHz with 8MB L3 Cache.
  - Memory: Intel Optane 24GB @3200MHz CL29
  - GPU: NVIDIA GeForce GTX1650Ti 1024C with base @1035MHz and max @1200MHz and 4GB GDDR5X VRAM.
- Software:
  - OS:x64 based Windows 10 Home version 22H2 - build 19045.3448
  - Programming Language: Python v3.10
  - Framework: PyTorch v2.0.1 with CUDA v10.0.130 - build 411.31
- Weather Condition: Foggy

EXPERIMENT PARAMETERS OF OUR WORK

TABLE 2: Experiment Parameters of Our Work

Experiment Parameters	**Value**
Dataset	Fog Dataset with various vehicles
Train, Valid, Test Data Size	80%, 10%, 10% of dataset
Training Framework	PyTorch
Batch Size	10
Epochs	10
Number of Classes	6

TABLE 3: Performance Metrics of Our Work

Performance Metrics	**Formula**
Average Precision	(TP)/(TP+FP)
Mean Average Precision(mAP)	Mean of Average Precision of all classes

Works To Be Done

- To train the model with a proper annotated dataset for 1st iteration.
- To expand the train dataset in an iterative manner.
- To maintain or to increase the accuracy with increased dataset size.
- To expand the objects classification by empowering domain adaptation with depth-embedding for specific feature extraction.

References

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[4] Farhodov, X., Kwon, O. H., Kang, K. W., Lee, S. H., Kwon, K. R. (2019, November). Faster RCNN detection based OpenCV CSRT tracker using drone data. In 2019 International Conference on Information Science and Communications Technologies (ICISCT) (pp. 1-3). IEEE.

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THANK YOU