D7047E - Project Assignment 1

Vehicle Detection in Challenging Snow Environments using Deep Learning

Group 16

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1 Problem Statement

The project focuses on developing a robust and accurate vehicle detection system capable of operating effectively in snowy conditions. Detecting vehicles in snow presents significant challenges due to reduced visibility, varying lighting conditions, and the similarity in appearance between snow and vehicles. This project aims to address these challenges using advanced deep learning techniques using Nordic Vehicle Dataset (NVD).

2 Intended Approach

2.1 Type of Problem

Object Detection. This is a computer vision task that involves identifying and locating objects (vehicles) within an image or video frame.

2.2 Initial Plan

- **Data Analysis** Thoroughly analyze the NVD dataset to understand its characteristics, including image resolution, snow conditions, vehicle types, and annotation formats. This will involve visualizing sample images and distributions of bounding box sizes.
- **Baseline Model** Implement and evaluate the performance of the YOLOv9 architecture as a baseline. This will involve:
  - Downloading and setting up the YOLOv9 codebase.
  - Preprocessing the NVD dataset to be compatible with YOLOv9.
  - Training the YOLOv9 model on the training split of the NVD dataset.
  - Evaluating the trained model on the validation split.

- **Model Enrichement** Explore techniques to improve the baseline performance, focusing on the challenges posed by snow.
  - Data Augmentation: Apply data augmentation techniques to increase the robustness of the model to variations in snow conditions, lighting, and vehicle appearance. This may include:
    * Adding synthetic snow or snow effects.
    * Adjusting brightness and contrast.
    * Blurring and noise addition.
    * Geometric transformations (rotation, scaling, flipping).
  - Loss Function Modification: Investigate modifications to the YOLOv9 loss function to better handle the challenges of detecting vehicles in snow. This could involve adjusting the weights of different loss components or exploring alternative loss functions.
  - Transfer Learning: Utilize pre-trained weights from models trained on large-scale datasets (e.g., COCO) to improve initial performance and accelerate training. Fine-tune these pre-trained models on the NVD dataset.
  - Ensemble Methods: Explore ensembling multiple models or different versions of YOLOv9 to improve overall accuracy and robustness. We will use PyTorch or TensorFlow based on team preferences and ease of integration with YOLOv9.
- **Evaluation Metrics**
  - **Mean Average Precision (mAP)**: The primary evaluation metric. Calculate mAP at different Intersection over Union (IoU) thresholds (e.g., mAP@0.5, mAP@0.5:0.95) to comprehensively assess performance.
  - **Precision and Recall**: Calculate precision and recall to understand the trade-off between correctly identifying vehicles and minimizing false positives/negatives.
  - **F1-score**: Compute the F1-score to provide a balanced measure of precision and recall.
  - **Inference Time**: Measure the time taken for the model to process a single image to assess its real-time applicability.
- **Potential Modifications**
  - Adjusting the weights of the classification, regression, and loss components to prioritize accurate localization in snowy conditions.
  - Exploring Focal Loss to address class imbalance, if certain vehicle types are underrepresented in the dataset.