Iran University of Science and Technology
Department of Computer Science

Assignment #3

YOLOv11 Instance Segmentation and Model Evaluation in Adverse Conditions

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Submission Deadline: *May 15, 2025*

Objective

The purpose of this assignment is to assess the performance of **YOLOv11-seg** models for instance segmentation of four object classes: *car*, *bus*, *pedestrian*, and *traffic light*. You will simulate scenes using the CARLA simulator under various weather conditions and evaluate how well different model variants perform in challenging environments. This assignment integrates simulation, data analysis, deep learning, and critical evaluation.

Assignment Tasks

1. Dataset Generation in CARLA

- Create a highly congested traffic scenario using the CARLA simulator.
- Mount one RGB and one instance segmentation camera on the ego-vehicle.
- Ensure frame-level synchronisation between both cameras to use segmentation as ground truth.
- Simulate and collect data for the following conditions:
  - Daytime
  - Nighttime
  - Rain

  - Fog
- Ensure class balance and sample sufficiency for deep learning training.

2. Dataset Analysis

- Report:
  - Number of samples per weather condition.
  - Number of object instances per class.
  - Total annotated instances.
- Provide relevant visualisations.
- Justify dataset volume and diversity for training.

3. Annotation Pre-processing

- Convert instance segmentation masks into YOLOv11-compatible annotations.
- Refer to the Ultralytics repository for format guidance.
- Ensure the correctness of annotation files before proceeding.

4. Data Augmentation

- Use Albumentations or Roboflow for:
  - Rotation, flipping, brightness, contrast adjustments.
- Justify and visualise your chosen augmentations.
- Compare class instance distribution pre- and post-augmentation.

5. Model Training

- Split your dataset into training, validation, and testing sets.
- Train three YOLOv11-seg variants:
  - YOLOv11n-seg (nano version)
  - YOLOv11m-seg (medium version)

  - YOLOv11l-seg (large version)

- Include training and validation loss/accuracy plots.
- Report the hyperparameters utilised for training each model and justify the reasons associated with the selection of such a set of parameters.
- Report and compare the training time of each model.

6. Model Evaluation

- Evaluate each model on each weather condition.
- Report:
  - Mean Average Precision (mAP)
  - Inference time
- Discuss:
  - Performance across weather conditions.
  - Class-specific performance analysis.

7. Final Report

Your final submission should include a concise report in a professional academic format. Suggested structure:

- Introduction
- Dataset Generation and Analysis
- Pre-processing
- Data Augmentation
- Model Training
- Evaluation
- Discussion
- Conclusion

Recommended length: 6–8 pages.

Optional Tasks for Bonus Marks

Complete any of the following for up to 20% additional marks:

- Integrate **Weights & Biases (W&B)** or **TensorBoard** for visualising training. (+5%)
- Apply **model pruning or quantization** for optimising inference time. (+5%)
- Export the model from PyTorch to TensorRT and compare the inference speed for pre-processing, main inference, and post-processing between PyTorch and TensorRT. (+5%)
- Proposing potential solutions to improve the generalisation capability of the models.

Submission Requirements

- PDF report in academic format.
- Source code (pre-processing, training, evaluation).
- Model files and logs (training and evaluation).

Please email your files as a single zip file by the specified deadline.

Final Note

This assignment is designed to simulate a real-world AI development project in autonomous driving. You are encouraged to think critically, conduct rigorous experiments, and present your results.

Good luck—and treat this assignment as a mini research project! The skills you gain will directly support your future in academia or industry.