

DESCRIPTION OF WORK

for

BLG 506E

COMPUTER VISION

COURSE PROJECT

Vehicle Detection and Classification from Images

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13.11.2023

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1 EXECUTIVE SUMMARY

In this project, the aim is to classify vehicles in an image. There are two main objectives in this project which will be represented by CV (computer vision) models. Transfer learning methods will be used; therefore, pre-trained models will be evaluated. In summary, Ali Şentaş will be responsible for training the model that detects the vehicle in an image, draws bounding boxes around them and provide these images to the classifier model. Classifier model will be the responsibility of Melik Buğra Özçelik. This model will be trained to classify vehicles based on their types (car, truck, bus etc.).

2 INTRODUCTION

In the domain of autonomous driving, the aim is to train vehicles to learn driving without need of a human driver. To do that, an autonomous vehicle should make decisions itself based on the information that it gathers by observing the environment. Without other actors in traffic, it is a relatively easy task to gather information of surrounding structural objects using sensors. However, considering the road line markings and the other moving traffic actors, sensor capabilities themselves are not sufficient. In this case, CV plays an important role to handle this type of a task [1]. To detect road line markings and the traffic actors, state-of-the-art deep learning-based CV techniques might be useful [2]. Focusing on detecting the traffic actors -vehicles in the scope of this project- there are two sub tasks. Firstly, the vehicles around should be detected by a CV model and stored in bounding boxes that draws the borders of the vehicle. Secondly, the detected bounding boxes should be fed into another model that classifies the vehicle in it based on its type. For an autonomous vehicle, having the knowledge about the vehicle types around it is very crucial. Because, these vehicles are also moving and making their own decisions, and these decisions also can be clustered depending on their types. Namely, the autonomous vehicle can predict the next actions of the vehicles around. For instance, if the vehicle in front of it is a heavy truck, the autonomous vehicle should always be cautious. In this project, it is aimed to detect the vehicles in an image and classify them based on their types.

3 PROJECT DESCRIPTION

In this project, transfer learning methods will be used. To achieve better results in an as short as possible time, pre-trained CV models will be evaluated [3]. To “transfer” these pre-trained models in the problem of classifying vehicles, the dataset that will be used in training is very crucial. Luckily, there are plenty of open-source datasets are available in this field and they are easy to access via several platforms like Kaggle, HuggingFace or Open Research Europe.

3.1 Goals of Project

The main goal of the project is to implement a robust and efficient vehicle detection and classification system that can be used in several types of vehicles. This detection and classification can be used in several advanced driver-assistance systems (ADAS) and autonomous driving systems, enabling vehicles to be safer.

3.2 Impact of Solution

There are millions of vehicles driven every day, transporting billions of people. Any additional improvement in this ecosystem will have substantial effects on safety of millions of people, potentially saving thousands of people from serious injury or death. The proposed project aims to help driver assistance systems on improving the general safety of the vehicles by detecting surrounding vehicles and helping the emergency braking and lane change assistance systems.

3.3 SOTA

Traditional vehicle detection methodologies often used features extracted from images such as HOG [4], SIFT [5], Harr [6] etc... These features are used to train models such as AdaBoost or SVM.

Current widely used methods for vehicle detection comes in two forms. First one is two stage solutions which include generating candidate boxes in the first stage, and detecting whether this candidate box is a vehicle or not in the second stage. For these types of classifiers typically CNN based methods, mainly region based convolutional neural networks (R-CNNs) [7] are used. The primary goal of these models is to output bounding boxes and classes of the objects withing an image. Optimization research over the years led to creation of fast R-CNN and faster R-CNNs which are the current state of the art for two stage vehicle detectors.

Unlike two stage R-CNN based method, one stage detection methods do not require generating bounding boxes and instead these bounding boxes are detected at various locations in an image simultaneously with the classification of these objects. Current state-of-the-art in this area is YOLO [8] variant of object detectors. Doing the detection and object classification in a single step leads to improved performance over the first type of two-stage solutions.

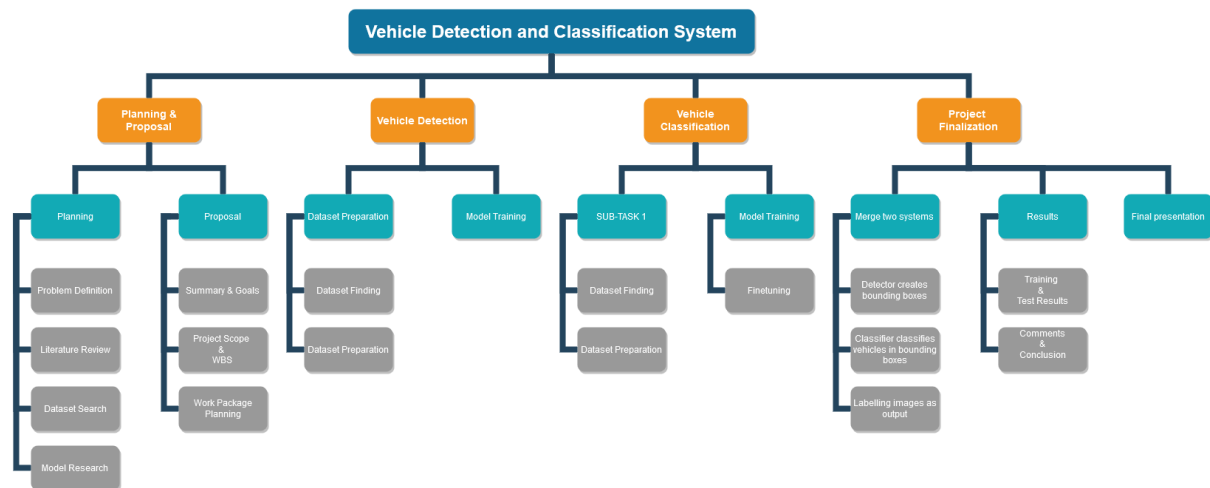
3.4 Risk Assessment

Possible Risk	Risk Reason	Contingency Plans
Limited data	Dataset	Augment the available data by means such as rotating images or adding noise.
Low quality dataset	Dataset	Find better datasets
Low model accuracy	Model training	Tune hyperparameters, find best performing ones
Overfitting	Model training	Add regularization such as dropout layers and/or simplify model
Underfitting	Model training	Increase the amount of data, tune hyperparameters
Slow performance	Model evaluation	Use simpler, less resource hungry models or use stronger GPUs

4 PROJECT SCOPE

This SOW shall apply to the tasks, services and terms detailed below:

4.1 Work Breakdown Structure (WBS)



4.2 Work Packages

WP 1	Planning & Proposal		
01.11.2023		13.11.2023	M1
Objectives: This work package will cover all tasks related to initial project planning and dataset & model research. This research will include literature review in this area.			
Tasks <ul style="list-style-type: none"> <input type="checkbox"/> Problem definition <input type="checkbox"/> Literature review <input type="checkbox"/> Dataset search <input type="checkbox"/> Model research 			
Deliverables and Milestones: <p>D1.1: Project proposal and presentation</p>			

WP 2	Vehicle Detection		
14.11.2023		04.12.2023	M5
Objectives: This work package will cover preparing vehicle detection pipeline, mainly the vehicle detector model which will be trained on this task. The knowledge from literature review conducted in WP 1 will be utilized here to find the dataset and CV model architecture to train this model.			
Tasks <ul style="list-style-type: none"> <input type="checkbox"/> Dataset research <input type="checkbox"/> Model training 			

Deliverables and Milestones:

D2.1: Project progress report

D2.2: Vehicle detection pipeline

MS2.1: Creation of vehicle detector model

MS2.2: Vehicle detector model training

MS2.3: Vehicle detector model testing

WP 3	Vehicle Classification		
14.11.2023		04.12.2023	M5
Objectives: This work package will cover preparing vehicle classification pipeline, mainly the vehicle classification model which will be trained on this task. The knowledge from literature review conducted in WP 1 will be utilized here to find the dataset and CV model architecture to train this model. This work will be done side by side with the detection pipeline since these models have different architectures, requirements and outputs.			
Tasks <input type="checkbox"/> Dataset research <input type="checkbox"/> Model training			
Deliverables and Milestones: D3.1: Project progress report D3.2: Vehicle classification pipeline MS3.1: Creation of vehicle classifier model MS3.2: Vehicle classifier model training MS3.3: Vehicle classifier model testing			

WP 4	Project Finalization		
04.12.2023		25.12.2023	M8

Objectives: This work package will cover merging the two pipelines prepared in WP 2 and WP 3 together to create the vehicle detection and classification pipeline. This final pipeline will be the output of this project which can then be used in the downstream vehicle ADAS pipelines. The training and testing results will also be published in the final report.

Tasks

- ☐ Merge two pipelines
- ☐ Prepare training and test results
- ☐ Prepare project report and presentation

Deliverables and Milestones:

D4.1: Project report

D4.2: Project presentation

4.3 Out of Scope

The following are considered OUT OF SCOPE for this contract:

1. Traffic object detection that are not vehicles. The detection of objects such as trees, road markings and traffic lights are left out of scope of this project.
2. Speed and movement detection of detected vehicles are left out of scope as it requires additional CV processes such as object tracking from one frame to another.

5 ASSUMPTIONS

This project assumes the following for the duration of the project:

1. There will be available datasets in the time of beginning of the project to train the detector and classifier models.
2. There will be available resources to train/finetune the models on a timely manner as well as doing validation and hyperparameter tuning.
3. Overall scope of the project will not change and there will not be additional tasks needed.

6 MILESTONES and DELIVERABLES

6.1 Deliverables and Milestone Tables

Deliverable (D)	Description	Date
D1.1	Project proposal and presentation	M1
D2.1	Project progress report	M5
D2.1	Vehicle detection pipeline	M4
D3.1	Project progress report	M5

D3.2	Vehicle classification pipeline	M4
D4.1	Project report	M8
D4.2	Project presentation	M8

Table 1 Deliverable Table

Milestone (MS)	Date	Deliverables
MS2.1	M2	Creation of vehicle detector model
MS2.2	M3	Vehicle detector model training
MS2.3	M3	Vehicle detector model testing
MS3.1	M2	Creation of vehicle classifier model
MS3.2	M3	Vehicle classifier model training
MS3.2	M3	Vehicle classifier model testing

6.2 Project Schedule (Gantt Chart)

Weeks	M1	M2	M3	M4	M5	M6	M7	M8
Starting	6.11.2023	13.11.2023	20.11.2023	27.11.2023	4.12.2023	11.12.2023	18.12.2023	25.12.2023
WP 1	D1.1							
WP 2		MS2.1	MS2.2, MS2.3	D2.2	D2.1			
WP 3		MS3.1	MS3.2, MS3.3	D3.2	D3.1			
WP 4								D4.1, D4.2

7 References

[1] Janai, Joel, Fatma Güney, Anurag Behl, and Andreas Geiger. "Computer vision for autonomous vehicles: Problems, datasets and state of the art." Foundations and Trends® in Computer Graphics and Vision (2020).

[2] Zablocki, Éloi, Hedi Ben-Younes, Patrick Pérez, and Matthieu Cord. "Explainability of deep learning-based autonomous driving systems: Review and challenges." International Journal of Computer Vision (2022).

[3] Chen, Chenyi, Ari Seff, Alain Kornhauser, and Jianxiong Xiao. "Deepdriving: Learning affordance for direct perception in autonomous driving." Proceedings of the IEEE International Conference on Computer Vision. 2015.

[4] McConnell, Robert K. "Method of and apparatus for pattern recognition." U.S. Patent No. 4,567,610. 28 Jan. 1986.

[5] Lowe, David G. "Object recognition from local scale-invariant features." *Proceedings of the seventh IEEE international conference on computer vision*. Vol. 2. Ieee, 1999.

[6] Viola, Paul, and Michael Jones. "Rapid object detection using a boosted cascade of simple features." *Proceedings of the 2001 IEEE computer society conference on computer vision and pattern recognition. CVPR 2001*. Vol. 1. Ieee, 2001.

[7] Girshick, Ross, et al. "Rich feature hierarchies for accurate object detection and semantic segmentation." *Proceedings of the IEEE conference on computer vision and pattern recognition*. 2014.

[8] Redmon, Joseph, et al. "You only look once: Unified, real-time object detection." *Proceedings of the IEEE conference on computer vision and pattern recognition*. 2016.