ME5413: Autonomous Mobile Robot

Homework 1: Perception

AY2024/25-Sem 2

Due date: 20 February 2025 - 2359 (Thurs, Week 6)

Important note: All homework is meant to be done in Python. Late submission be penalised. First hour 5%, and every hour after that 5% of the grade. No Plagiarism is allowed.

Introduction: The aim of this assignment is to get students to familiarise themselves with perception algorithms and ROS.

Requirements: *Python 3.9 and higher and ROS Noetic*

Task 1: Single Object Tracking [60%]

Object Tracking (SOT) has a wide-range of applications spanning from surveillance and robotic, where accuracy and robustness are paramount. In this project, students are tasked to implement a Single Object Tracking algorithm on a series of images. The object of interest, the object to be tracked is found in `<firsttrack.txt>`. The format of a bounding box is as `[x, y, width, height]`. e.g. [137, 320, 233, 191]. Ground truth values: `<groundtruth.txt>`, and must only be used for **evaluation.**

Figure 1.1: Example of visualisation of first track. Red refers to Ground Truth.

1. Implement the following (Single Object Tracking) SOT methods with:
Please indicate your results in the following results file name.

i. Template matching *(Results file: **trackresults_TM_seqX.txt)***
ii. Object Detection Algorithm with Association
(Results file: **trackresults_ODA_seqX.txt)**
You are provided with a simple Object Detection Neural Network, information on the neural network can be found here:
https://huggingface.co/docs/transformers/en/model_doc/detr.
The final bounding boxes are in (top_left_x, top_left_y, bottom_right_x, bottom_right_y) format.
iii. Propose **ONE** improved method (e.g. different neural network/association metric. *Retraining/Training a neural network training is NOT allowed.*)
(Results file: **trackresults_improved_seqX.txt)**

Please ensure that your format of tracking bounding box is [x, y, width, height]. e.g. [173,294,121,190]

2. **Evaluate & Visualise** the performance of the Single object tracking algorithm for each of the 5 sequences using One-Pass Evaluation Metric's **Precision** and **Success** metric, as discussed in Lecture 3 and below.
Precision P: is usually measured as the distance in pixels between the *centers of the ground truth*, C_{gt} and *centers of the tracker bounding box*, C_{tr} . The trackers are ranked using this metric with a threshold of *t* pixels. *Please state the thresholds used.*
Success S: the Intersection over Union (IoU) of the pixels between the ground truth bounding boxes (BB_{gt}) and the ones generated by the trackers (BB_{tr}). *Please state the thresholds used.*

$$Success = \frac{BB_{tr} \cap BB_{gt}}{BB_{tr} \cup BB_{gt}}; Precision = ||C_{tr} - C_{gt}||_2$$

Note: *When visualising your results, please ensure that the groundtruth boxes and tracking boxes are of different colours, and that their colours are indicated.*

Please include the following result tables in your report:

Table 1.1 Evaluation of SOT methods using ***Precision*** metrics

		Seq 1	**Seq 2**	**Seq 3**	**Seq 4**	**Seq 5**	**Average Score**
1	**Template Matching**						
2	**Detection with Association**						
3	**Improved Method**						

Table 1.2 Evaluation of SOT methods using ***Success*** metrics

		Seq 1	**Seq 2**	**Seq 3**	**Seq 4**	**Seq 5**	**Average Score**
1	**Template Matching**						
2	**Detection with Association**						
3	**Improved Method**						

Task 2: Multi Object Prediction [40%]

1. Using constant velocity model to predict the future 3,5,8 seconds trajectories of all the target agents and calculate the ADE and FDE.
2. Using constant acceleration model to predict the future 3,5,8 seconds trajectories of all the target agents and calculate the ADE and FDE.
3. Visualize at least 10 prediction results. Briefly discuss the observations from your results.

Bonus Task: Single Object Tracking in ROS [Bonus 10%]

Using your best algorithm from Task 1, apply single object tracking to the given set of rosbags.

There are three topics you need to write a publisher for, and the corresponding message types are indicated in Table 3.1. Save the rosbags in the folder: /results/4_rosbags

Table 3.1: ROS Publisher topics and examples

	Published Topics Description	**Message Type**	**Topic Names**
1	Visualize tracked object and gt object	sensor_msgs/Image *(viewed with **rviz** NOT cv2)*	/me5413/viz_output
2	Broadcast ground truth objects	vision_msgs/Detection2D	/me5413/groundtruth
3	Broadcast tracked objects	vision_msgs/Detection2D	/me5413/track
4	Publish NUSNET ID (i.e. number starting with E____)	std_msgs/String	/me5413/nusnetID

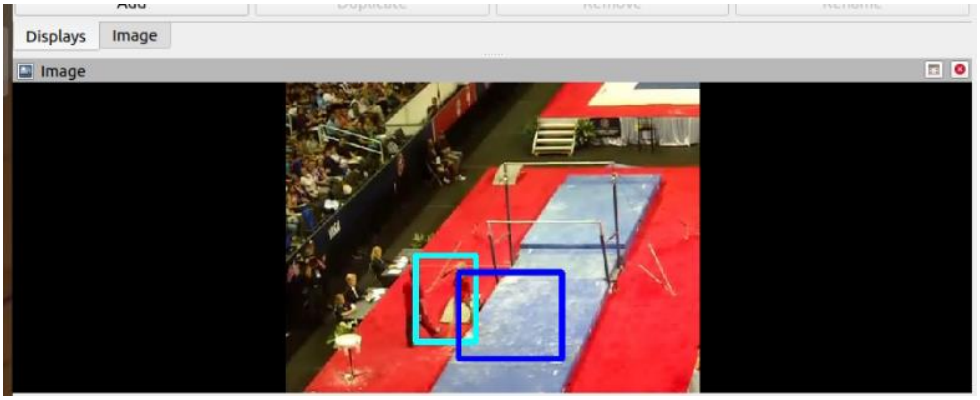

Figure 3.1: Example of visualized box, viewed from rviz.

Task 4: Evaluation

1. How much time did you spend on this homework for each task?

Submitting your completed Homework Assignment:

Generate a zipfile of this folder and upload it to CANVAS – under Assignment 1. *We will use the latest version.*

Name of Zipfile: "YourNusNetID_Homework1.zip" (e.g. E123456_Homework1.zip)

Submission Details:

Important – All code and report must be in English. Comments/words in other languages will be ignored.

1.	Report	1. Name 2. Matric number (i.e. number starting with A0..) 3. Maximum number of **5 pages** for the report (+2 pages for the bonus task, and not including front cover page) Font Times New Roman, 12pt Single Spaced 4. In PDF format (with similarity score < 20%)
2.	README.txt requirements.txt	Provide Instructions on how to run your code in a README file, Python version and required packages for installation in the requirements.txt. (*marks will be deducted if your code cannot be implemented*)
3.	Folder: Task 1	1. Code (Jupyter notebook) 2. Results: Location of tracked object in each frame (.txt file)
4	Folder: Task 2	1. Code (Jupyter notebook)
5.	Folder: Bonus Task	1. Code 2. Rosbag file with published topics