1 Autonomous Driving (11 Points)

(a) What are the five levels of autonomy according to SAE? (1 Point)

(b) Which levels do the following techniques belong to? (3 Points)

- Emergency brake assistance
- Autonomous parking
- Lane departure warning
- Traffic jam assist
- Advanced driving support system
- Collision avoidance system

(c) What are the three dominating paradigms for developing autonomous driving systems? (1 Point)

(d) Please explain the pros and cons of each paradigm in 75-100 words per paradigm. (6 Points)

2 Sensors in Autonomous Vehicles (5 Points)

Camera, Radar, and LiDAR are the most commonly used sensors in autonomous driving. All three types of sensors have their pros and cons. Therefore, a mixture of them is often used to complement their weaknesses.

(a) Please rank all the three sensors' performance according to the following standards *(one set of ranking for each standard listed below).* (3 Points)

- Resolution
- Resistance to different weather conditions
- Night vision

(b) Sensor fusion has been widely adopted for autonomous vehicles in complicated situations. However, under some conditions, it still can not guarantee a good reconstruction of the vicinity. Please name one situation where simply fusing the above three types of sensors fails and justify your answer. (2 Points)

3 Imitation Learning and Reinforcement Learning (4 Points)

(a) In imitation learning, the optimal action is normally assumed to only depend on the current state. This is, however, often violated in practice. Please explain the failure mode of the assumption in terms of steering angle prediction. What could be an alternative solution in this case? (2 Points)

(b) How does reinforcement learning differ from imitation learning in terms of the setting and the goal? (2 Points)

Submission Details:

Upload your submission to our CMS in groups of two to three students until *December 15, 2024 at 17:59.* Late submissions will not be graded! The submission should be uploaded by exactly **one** team member. Make sure that your submission contains the name and matriculation number of each team member. Submit your solution as a *pdf* file with your answers.

1.a) Five levels of autonomy according to SAE are No Automation, Driver Assistance, Partial Automation, Conditional Automation, High Automation, and Full Automation respectively from level 0 to level 5.

1.b) • Emergency brake assistance —> Level 0 (No Automation)
- Autonomous parking —> Level 4 (High Automation)
- Lane departure warning —> Level 0 (No Automation)
- Traffic jam assist —> Level 3 (Conditional Automation)
- Advanced driving support system —> Level 5 (Full Automation)
- Collision avoidance system —> Level 2 (Partial Automation)

1.c) These paradigms are Modular Pipelines, End-to-End Learning, and Direct Perception.

1.d) Modular Pipelines: Since there are many small components in modular pipelines, it is relatively easy to develop. Also, they are relatively interpretable because all components in the pipeline have been designed and developed by humans. On the contrary, it doesn't allow to train the models end-to-end. That is, individual modules have been trained independently from the actual task, which is self-driving. Moreover, localization and planning heavily relies on HD maps which require a lot of human labor to create and to keep up-to-date.

End-to-End Learning: Since they are end-to-end, they can be optimized for the actual task, which is the driving task. Furthermore, annotations are relatively cheap because the only requirement is to attach a camera to the car and few sensors to the steering wheel. On the other hand, these models lack interpretability because the whole system is trained end-to-end. For example, when there occurs a problem about the output of the model, the developer cannot easily understand the cause of the problem. Also, generalization is another disadvantage since these models may struggle in unseen conditions that are not part of training data.

Direct Perception: These models enable developers to have the right level of abstraction specific to task since it allows them to explicitly define intermediate representations. Additionally, they are quite interpretable thanks to these intermediate representations that humans can understand. In contrast, it comes with complexity because of intermediate representations; hence, choosing the ideal representation requires extensive thinking, which also involves human decisions. Additionally, in these models, vehicle control is not learned jointly, which can cause mismatches between intermediate representations and vehicle control.