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Self-Driving Cars: An Introduction

"Self driving is a regular car that has been instrumented"

- Equipped with sensors to perceive the surrounding (3D Lidar, Camera, GPS, IMU)
- Computer
- Instrumentation to control the car using computers.

★ What do self-driving cars need to do?

- ① Must have the right prior knowledge.
(MAP)
- ② Estimate the own state
- ③ Perceive the surroundings
- ④ Predict what is going to happen
- ⑤ Reason and plan what to do
- ⑥ Act - execute steering commands

⇒ Two key topics primarily addressed in this course:

- Perception
- Planning & Control

★ Levels of Autonomy (by SAE)

↓
{ Society of Automotive Engineers }

Level 0: No Automation

Level 1: Driver Assistance

Level 2: Partial Automation

→ Advanced Cruise control as the car can automatically take safety action but driver needs to stay alert.

Level 3: Conditional Automation

→ Some safety-critical functions performed by the vehicle, under certain conditions.
→ The human is still required.

Level 4: High Automation

→ Autonomous driving almost all the time without human input.
→ Driving may be limited to mapped areas and may not work under all weather conditions.

↳ No human interaction in regular operations.

Level 5: Full Automation

↳ Full automation in all conditions

★ Technology in Self-Driving Cars:

① Online state estimation

Localization, SLAM, Sensor fusion

② Machine learning / deep learning

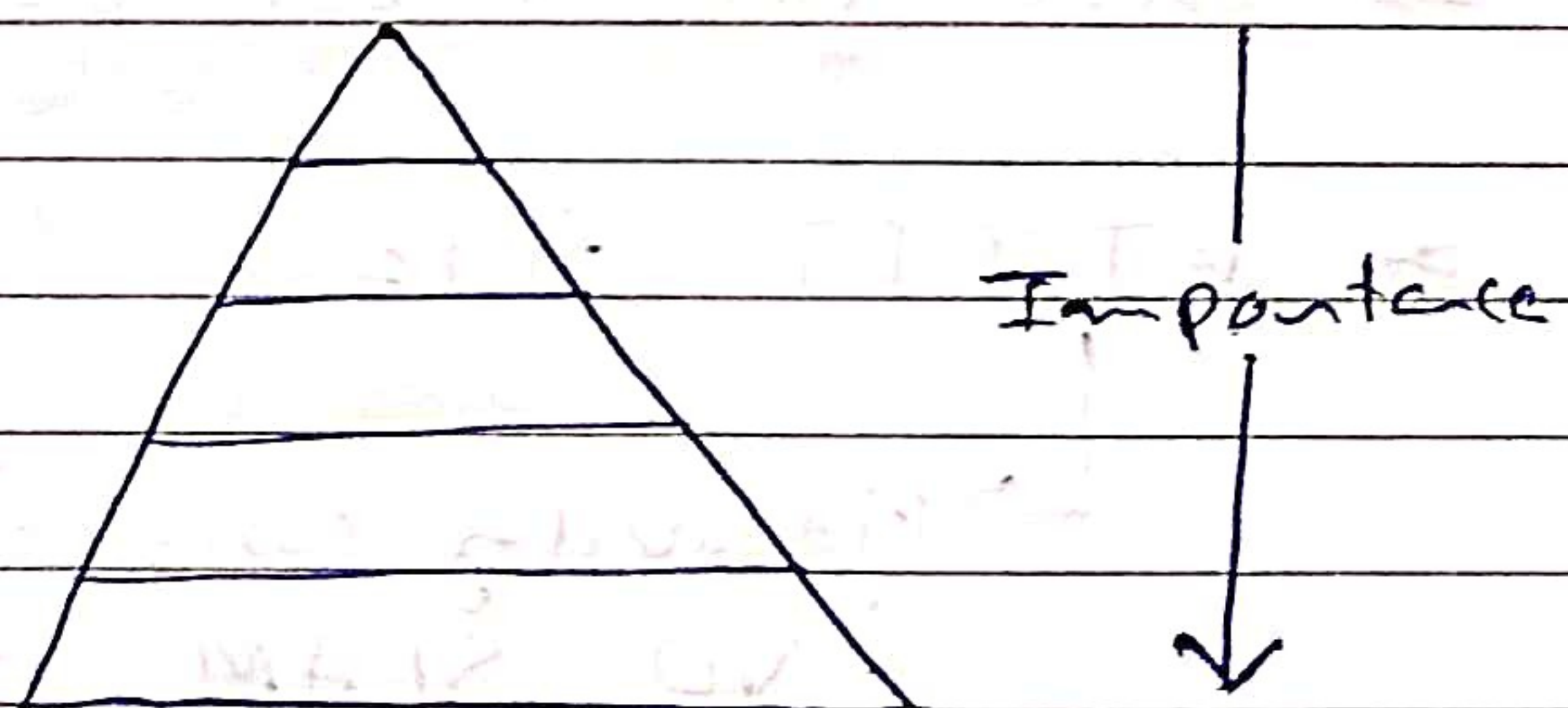
detection, Semantics, behavior prediction
imitation learning

③ Planning & Control

path planning, high-level behavior
, planning under uncertainty, control

★ What is most Important

- Route Efficiency
- Comfort
- Perceived Safety
- Legality
- Safety



* How to test the developments

- ⇒ Real testing is slow and expensive!
- ⇒ How to test at large scale?
- ⇒ How to evaluate different approaches objectively?
- ⇒ How to test behaviors in dangerous situations?
- ⇒ What happens after changes in the code base?
 - ↳ Run all real tests again?
- ⇒ How to get ground truth data?

① Datasets

- ⇒ Datasets recorded from vehicles are a key building block in development.
- ⇒ This doesn't work for all algorithms.

* KITTI dataset (2012)

- ↳ Heavily used for state estimation tasks (VO, SLAM, depth from vision)

* KITTI & Semantic KITTI

↳ A semantic label for every 3D point

* Oxford robotcar dataset

* highD dataset

* Waymo Open dataset

* nuScenes

* Panda Set

* Berkeley Deep Drive

* Argoverse

* Level 5 Open data

* ASTYX HIRES2019 Data Set

② Simulations

⇒ Allows for automated and parallel testing.

⇒ Can generate identical situations over & over again.

⇒ Allows for focusing on tricky situations

- ⇒ Allow for testing dangerous situations
- ⇒ Can provide ground truth data for learning algorithm.
- ⇒ Open Source simulator:
 - Carla

