Robotic Navigation and Exploration

Unit 1: Introduction

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直播連結 https://www.youtube.com/@NTHURNE-l9v

!!! Notice !!!

- 因座位與設備有限，清大加簽人數: 30人
- 本課程因名額有限，為避免影響他人權益，不接受期中退選，請三思是否選修!

Outline

- Syllabus
- 加簽生死戰
- Overview of Mobile Robot

Syllabus

Syllabus (Tentative)

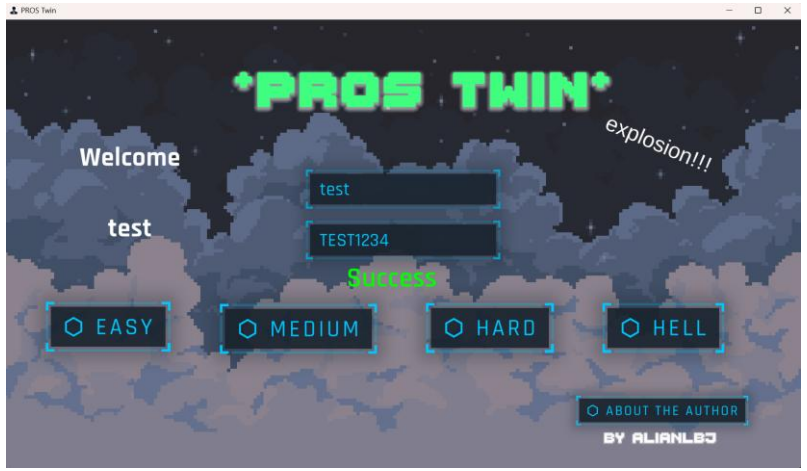
Grading

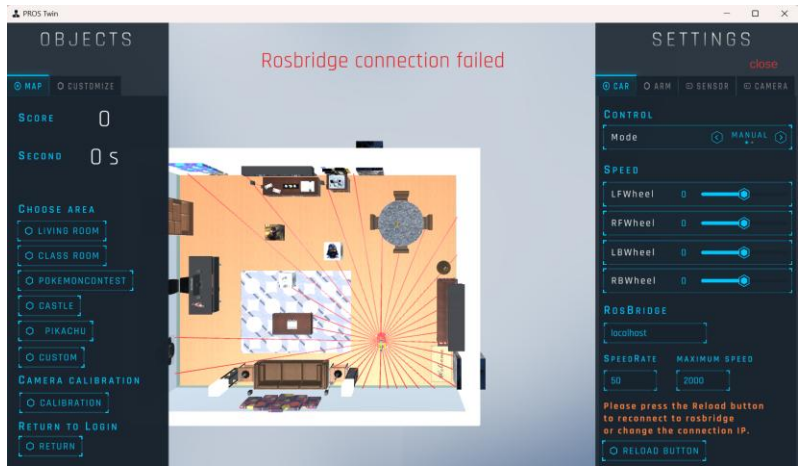
- Homework: 50%
  - HW1: Path Planning (10%)
  - HW2: Path Tracking (15%)
  - HW3: RL (PPO on Path Tracking) (15%)
  - HW4: Object Detection & Segmentation (10%)
- Paper Presentation: 10%
- Final Project: 40%

Week	Date	Topic
1	2/17	Syllabus & Overview
2	2/24	Motion Planning Lab 1: Path Planning + HW1
3	3/03	Kinetic Model & Path Tracking Control Lab 2: Path Tracking Control + HW2
4	3/10	Reinforcement Learning (I)
5	3/17	Reinforcement Learning (II) Lab 3: PPO + HW3
6	3/24	Computer Vision Basics Lab 4: YOLO + HW4
7	3/31	SLAM Back-end (I)
8	4/07	SLAM Back-end (II)
9	4/14	3D SLAM (I)
10	4/21	3D SLAM (II)
11	4/27(日)	Workshop (I) : 期末專題虛擬環境介紹與實作
12	5/04(日)	Workshop (II) : 實體車環境介紹與實作
13	5/12	3D Embodied Agent
14	5/19	Paper Presentation (I)
15	5/26	Paper Presentation (II)
16	6/02	Project Presentation & Demo Day

Agenda for the 1st Workshop (April 27)

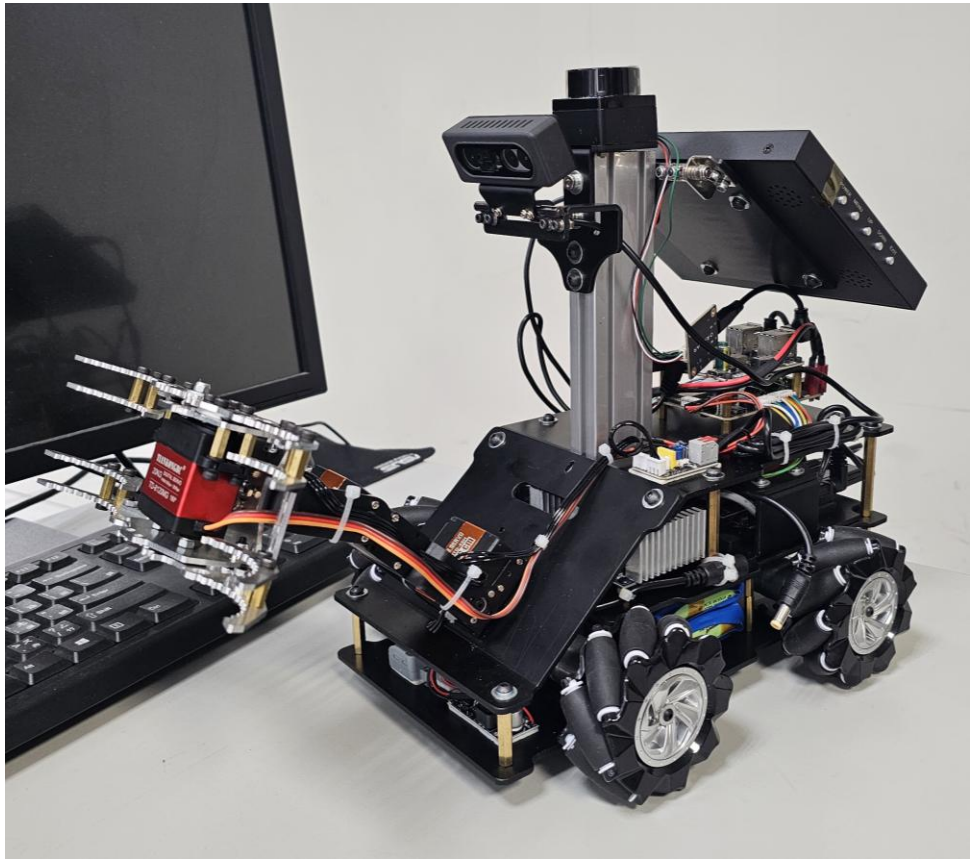
時間	主題
09:00~10:00	Foxglove介紹
10:00~11:00	ROS基礎知識
11:00~12:00	YOLO Integration
12:00~13:00	午休
13:00~14:00	YOLO/carControl node實作
14:00~17:00	比賽說明 + model training (自由發揮)





Agenda for the 2nd Workshop (May 4)

時間	主題
09:00~10:00	自走車硬體介紹與連接
10:00~11:00	自走車 SLAM & Localization
11:00~12:00	車用 Depth Camera & Yolo Detection
12:00~13:00	午休
13:00~17:00	實體車競賽說明與實作

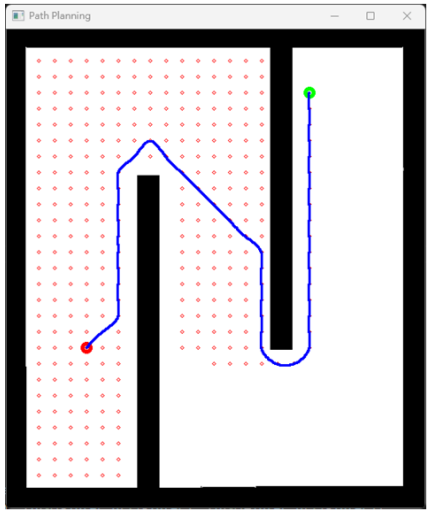


HW1:
Path Planning

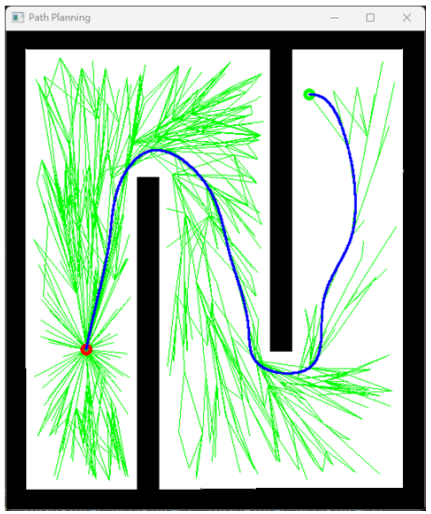
Score & Requirement

- **A*** (45%)
  - Implement path planning using A* algorithm
- **RRT*** (45%)
  - Implement path planning using RRT* algorithm
- **Report** (10%)

A*



RRT*



HW2:
Path Tracking

Score

- **Path Tracking**
  - PID (Basic / Differential Drive / Bicycle) (5+5+5=15%)
  - Pure Pursuit (Basic / Differential Drive / Bicycle) (10+10+10=30%)
  - Stanley (Bicycle) (10%)
  - LQR (Basic / Differential Drive / Bicycle) (10+10+10=30%)
- **Collision Handling** (5%)
- **Report** (10%)

HW3:
Deep Reinforcement Learning on Path Tracking

Score & Requirement

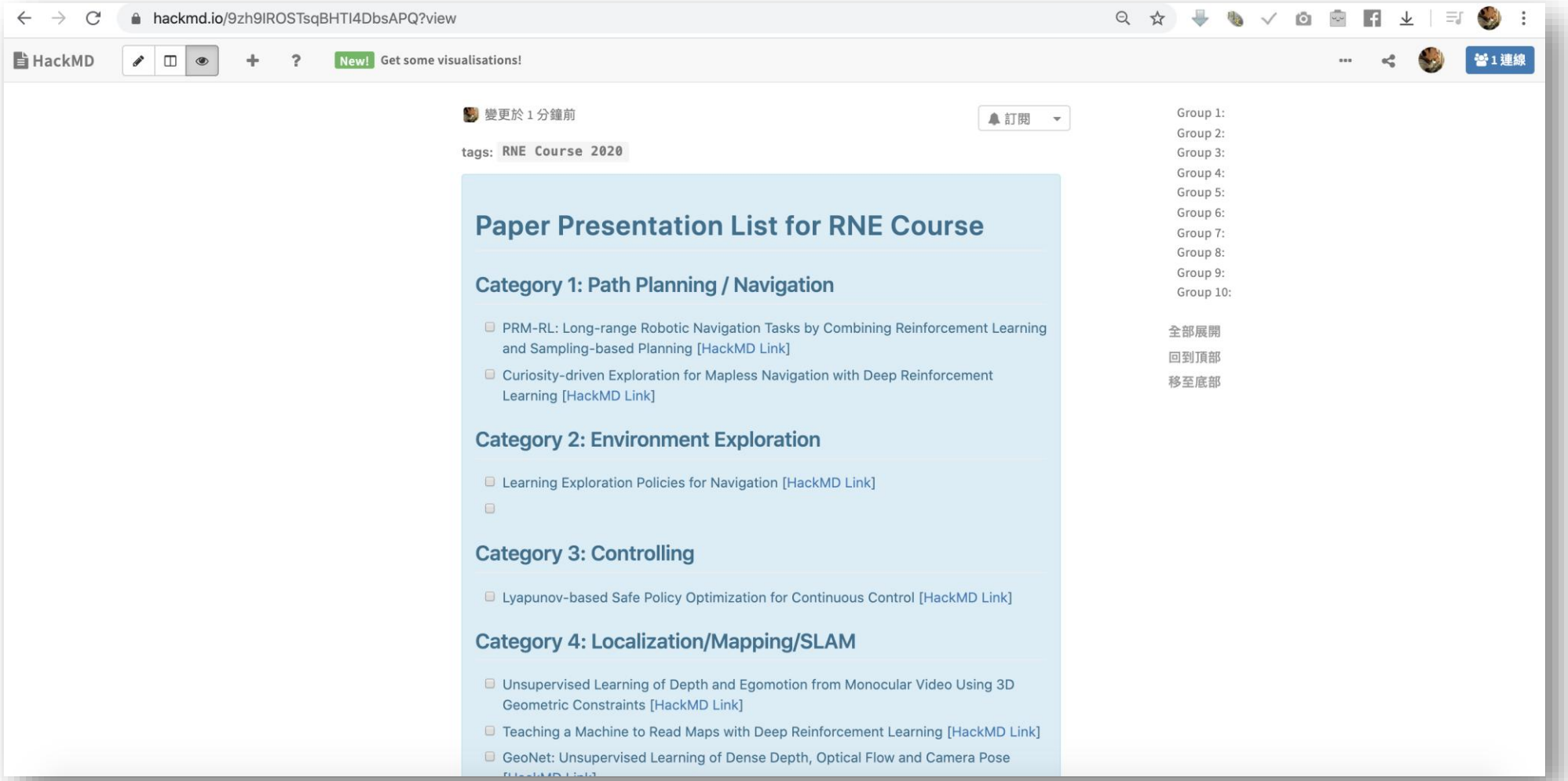
- Complete the code in “model.py”, “env_runner.py”, and “agent.py” and train the model. (TODO 1 ~ 4)
  - Score:
    - TODO 1(15%)
    - TODO 2(15%)
    - TODO 3(15%)
    - TODO 4(15%)
- After training, evaluate your model by executing “plot.py” and “eval.py”.
  - Score:
    - plot(10%)
    - evaluation(30%)
  - Evaluation:
    - 30 * ES / 120, where ES is your evaluation score (you will get 30 if ES > 120)

HW4:
Object Detection &
Semantic Segmentation

Score & Requirement

- **Object Detection** (45%)
  - Detect Pikachu using YOLO model
- **Semantic Segmentation** (45%)
  - Segment roads, walls, and obstacles
- **Report** (10%)

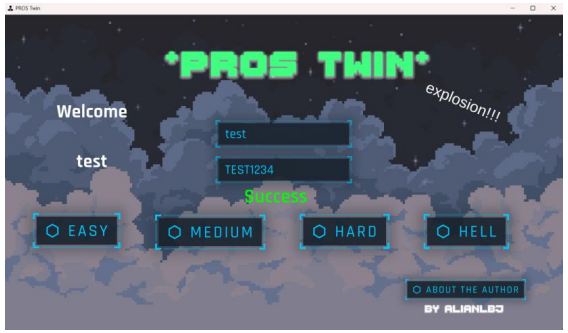
Paper Presentation

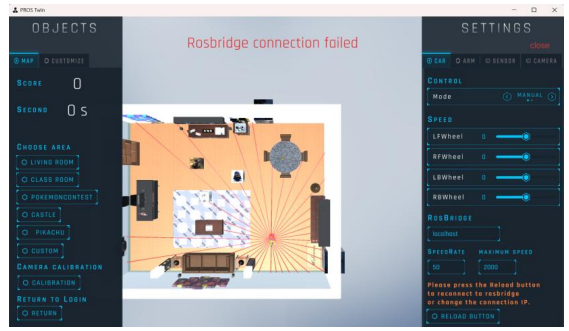


Final Project

Requirement

- **There are 4 levels and 3 Maps in total.**
- **4 Levels (Easy、Mid、Hard、Hell)**
  - **Easy : Contains Lidar + ArUco Markers + RGB-D information**
  - **Mid : Contains ArUco Markers + RGB-D information**
  - **Hard : Contains ArUco Markers + RGB information**
  - **Hell : Contains RGB information**
- **3 Maps**
  - **Living room、Open sesame、Pikachu**





Score

- **Basic Score for each level** 70%
  - **Map Living room (40%)**
    - fixed target (once) : 10% * w(t)
    - random target (3 times) : 10% * w(t) + 10% * w(t) + 10% * w(t)
  - **Map Open sesame (30%)**
    - random target (3 times) : 10% * w(t) + 10% * w(t) + 10% * w(t)
- **Final Score** Max(Easy、Mid、Hard、Hell) + Bonus
  - **Easy (70%)** : Basic Score 70%
  - **Mid (80%)** : Basic Score 70% + 10%
  - **Hard (90%)** : Basic Score 70% + 20%
  - **Hell (100%)** : Basic Score 70% + 30%
  - **Bonus (10%)** : Map Pikachu 10% * w(t)

w(t): 根據該關卡過關時間分布做分數加權

Dashboard > **Grade View**

Overview

Columns Filters Density Export

ID	Student ID	Username	Department	Time	Elapsed Time	Map	Sensor	Score
1	test	test	test	1/24/2025, 9:38:58…	4	Livingroom	Hard	100
2	test	test	test	1/24/2025, 9:41:04…	12	Castle	Hard	100
3	test	test	test	2/5/2025, 12:12:09…	71	Custom	Easy	16
4	test	test	test	2/7/2025, 1:41:13 …	38	Classroom	Easy	80
5	test	test	test	2/8/2025, 2:44:10 …	77	Pikachu	Easy	16

Rows per page: 20 1–5 of 5

NTHU TA

張博智

劉尚磬

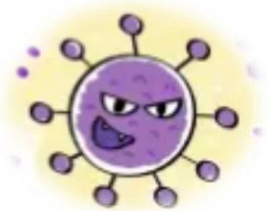
江佳臻

陳寬宸

陳永錩

Course Q&A

- Take attendance?
- Food?
- Zzz…?



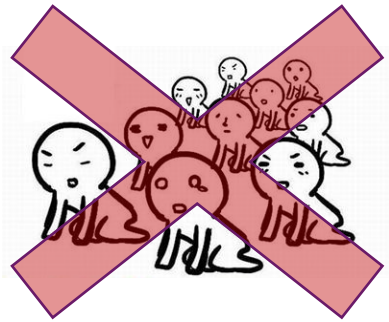
Be Responsible for Yourself

- Plagiarism will result in zero score

  ➔ Final score=0

- Under 60 or 70 ?

  ➔ See you next year ~

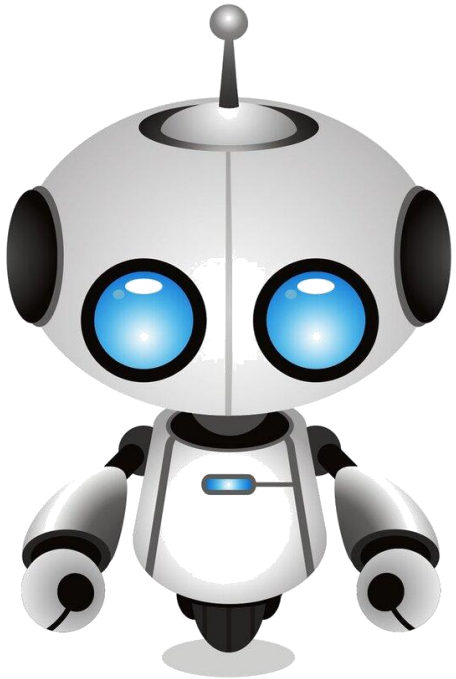


Any Question

想像力就是你的加簽力

What is a robot

A programmable, self-controlled, automatic device consisting of electronic, electrical, or mechanical units.

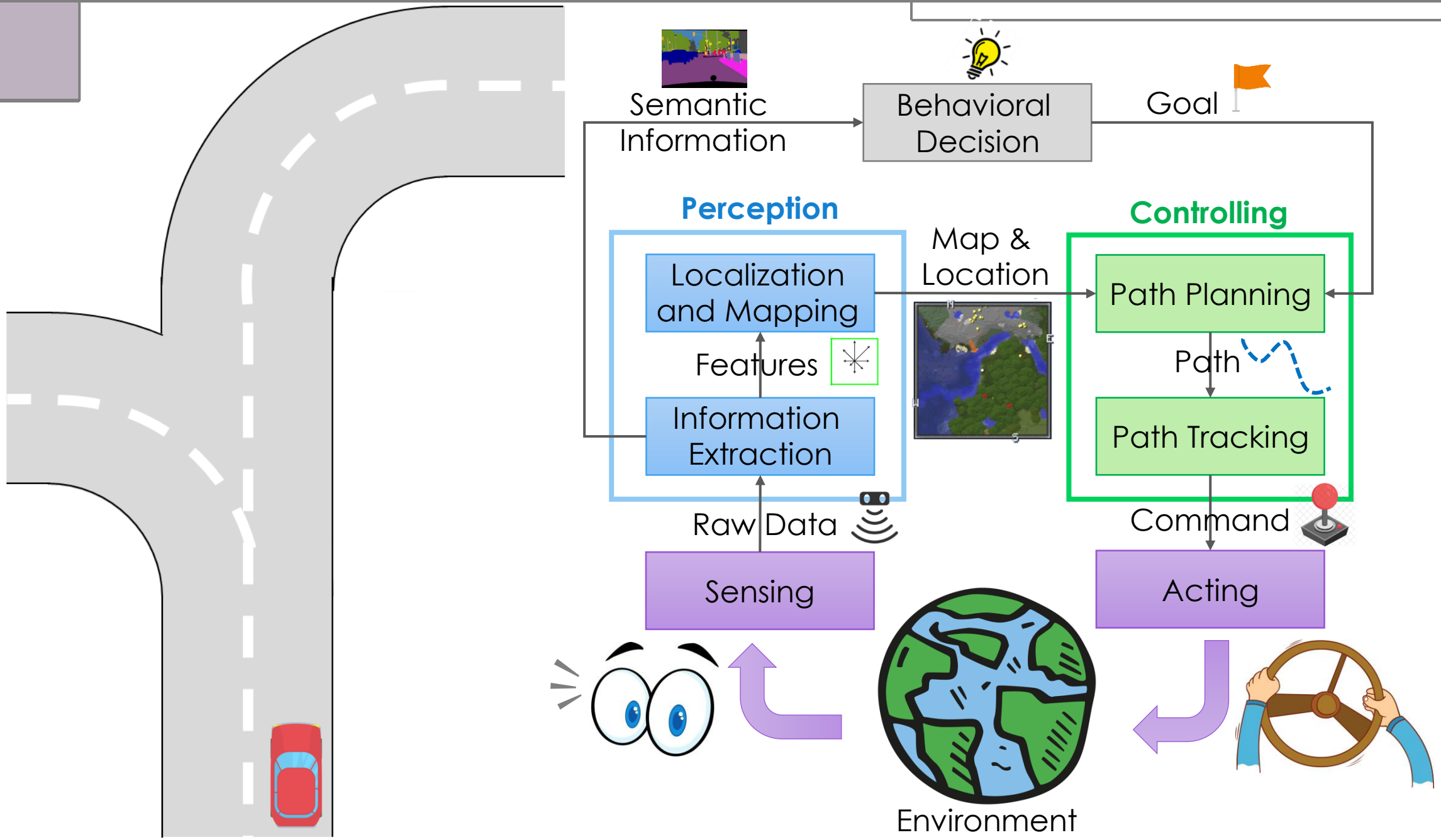


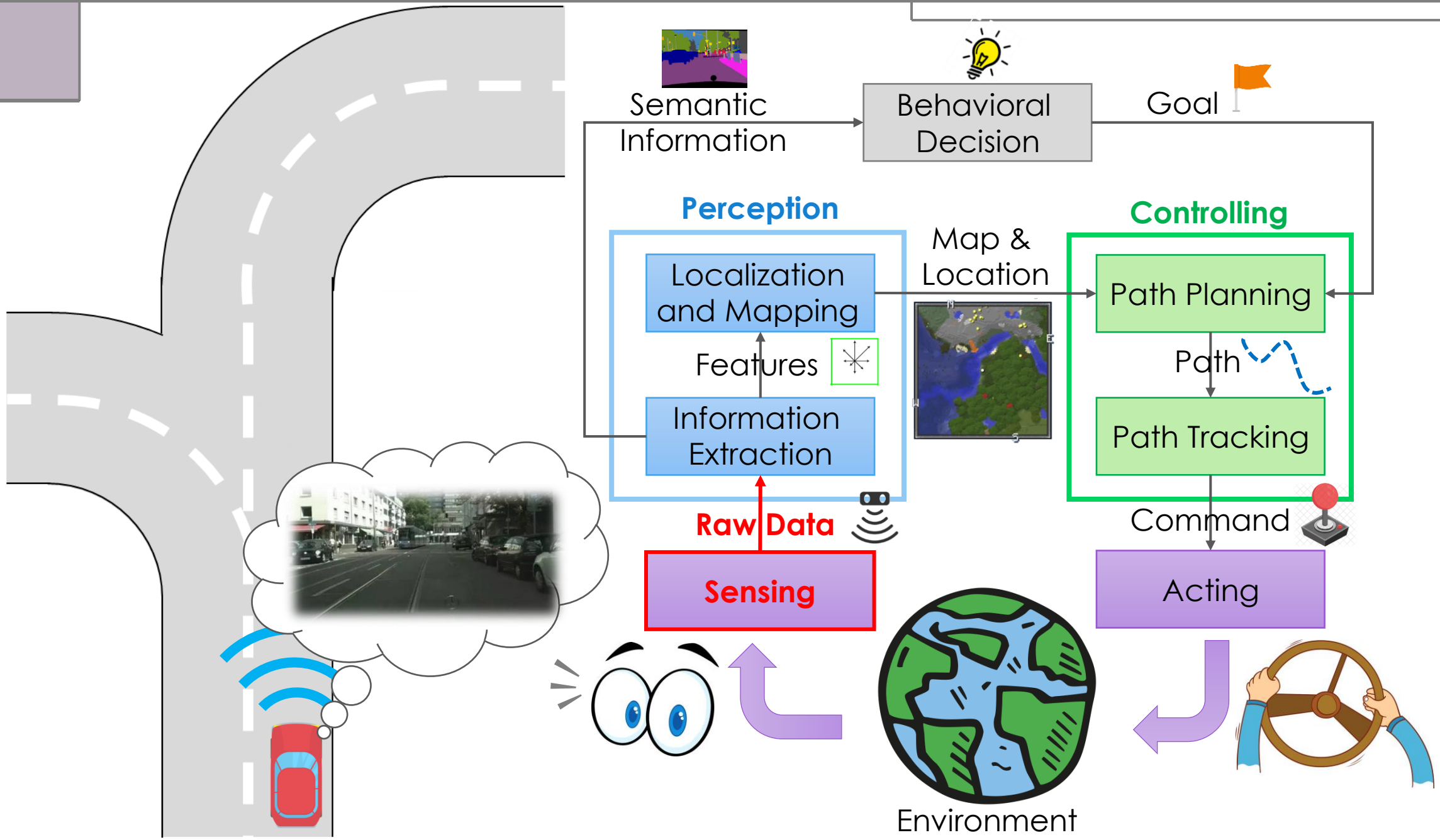
Mobile Robot in Your Mind

What technical components should be integrated into the mobile robot for optimal functionality?

Time's Up

Overview of Mobile Robot


Semantic Information
Behavioral Decision
Goal
Perception
Controlling
Localization and Mapping
Map & Location
Path Planning
Features
Path
Information Extraction
Path Tracking
Raw Data
Command
Sensing
Acting
Environment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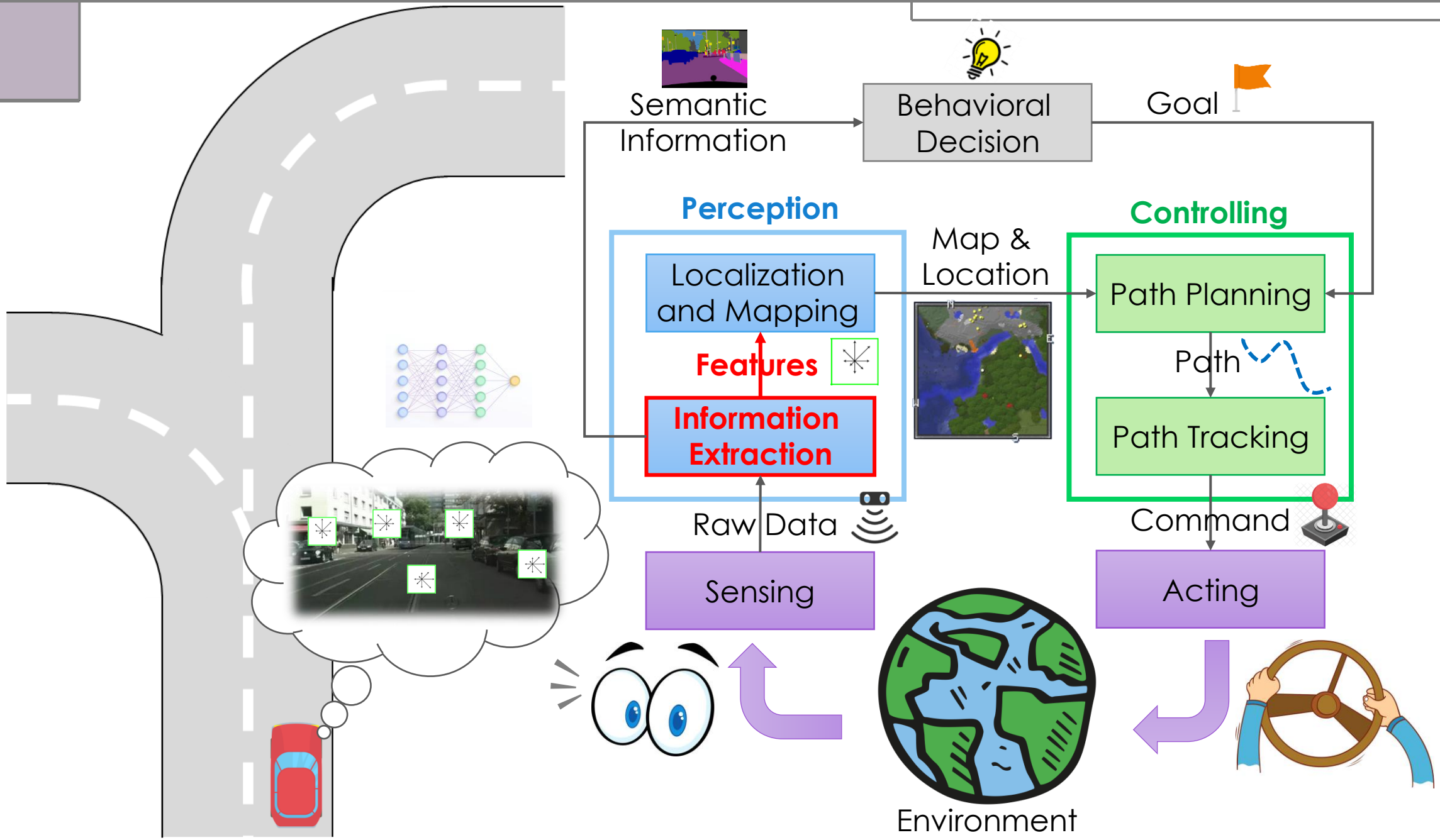
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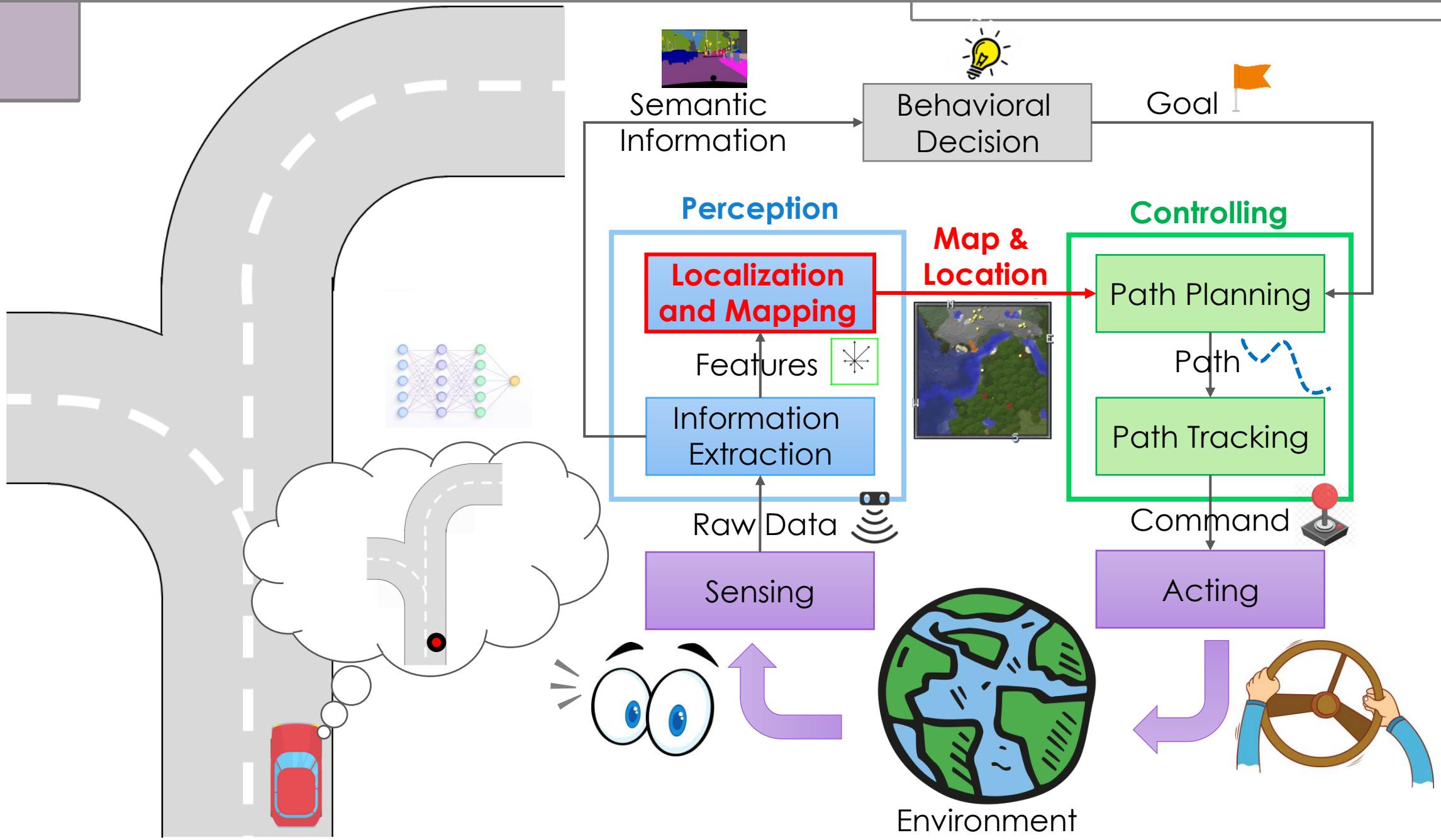
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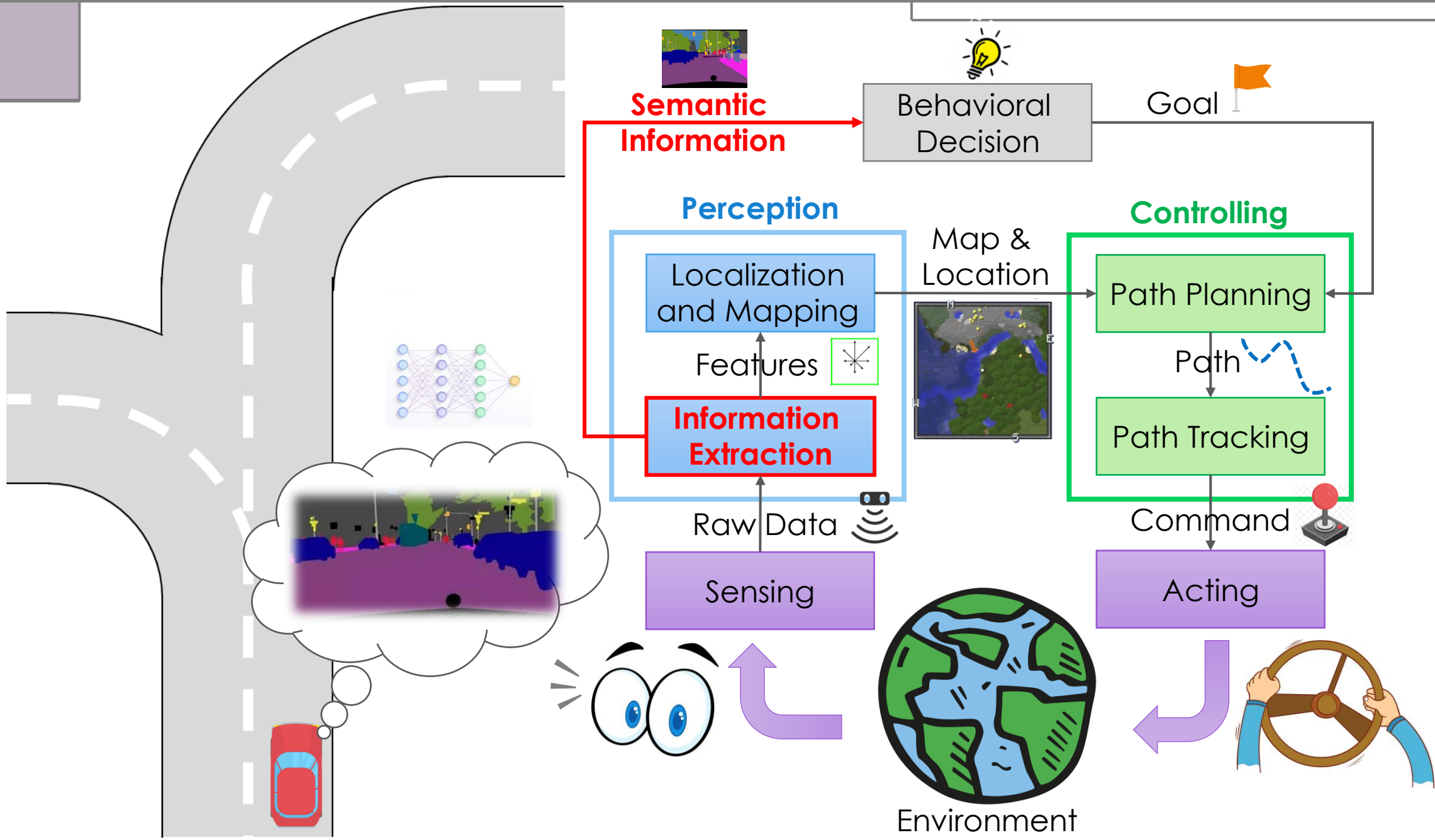
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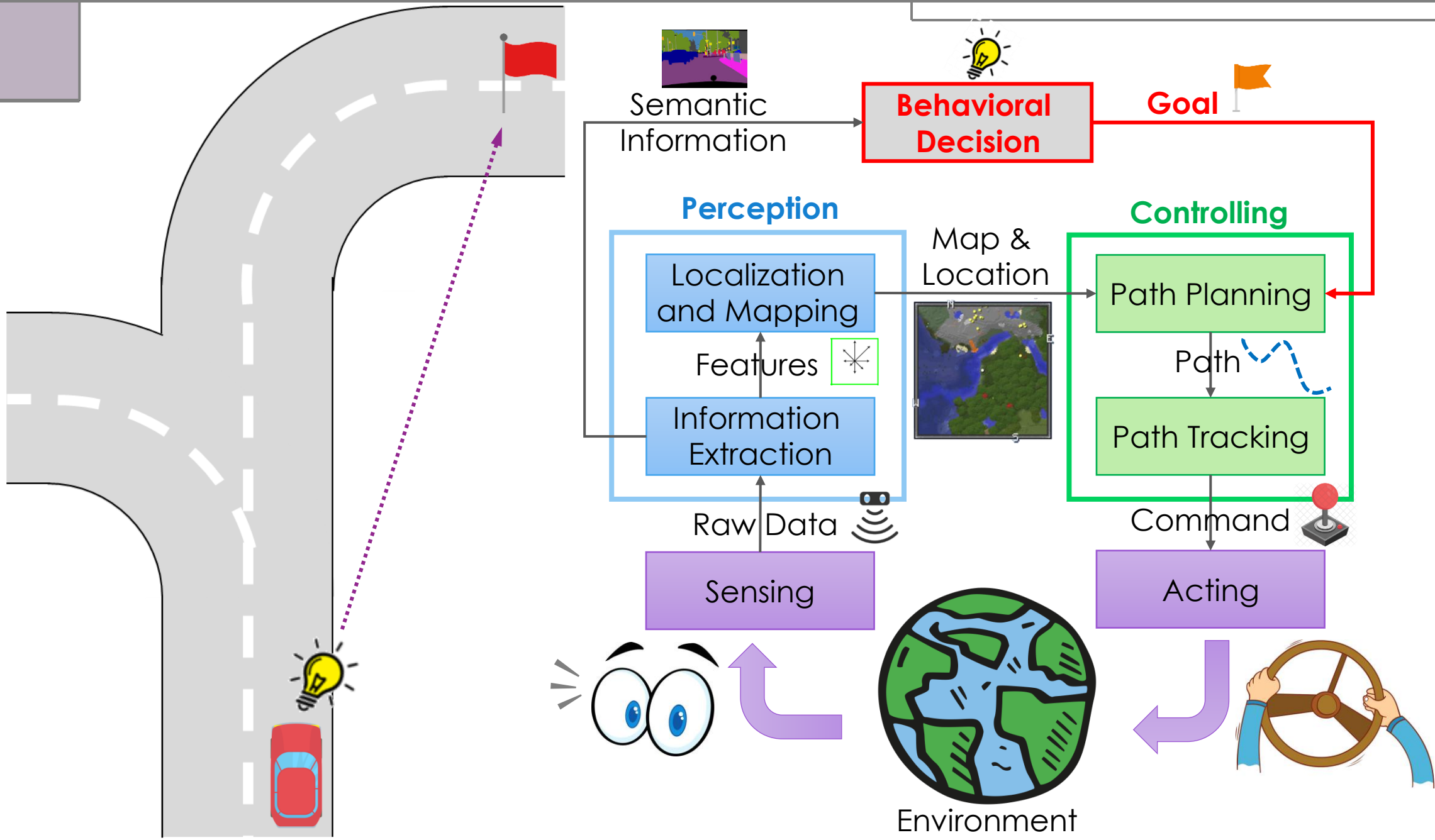
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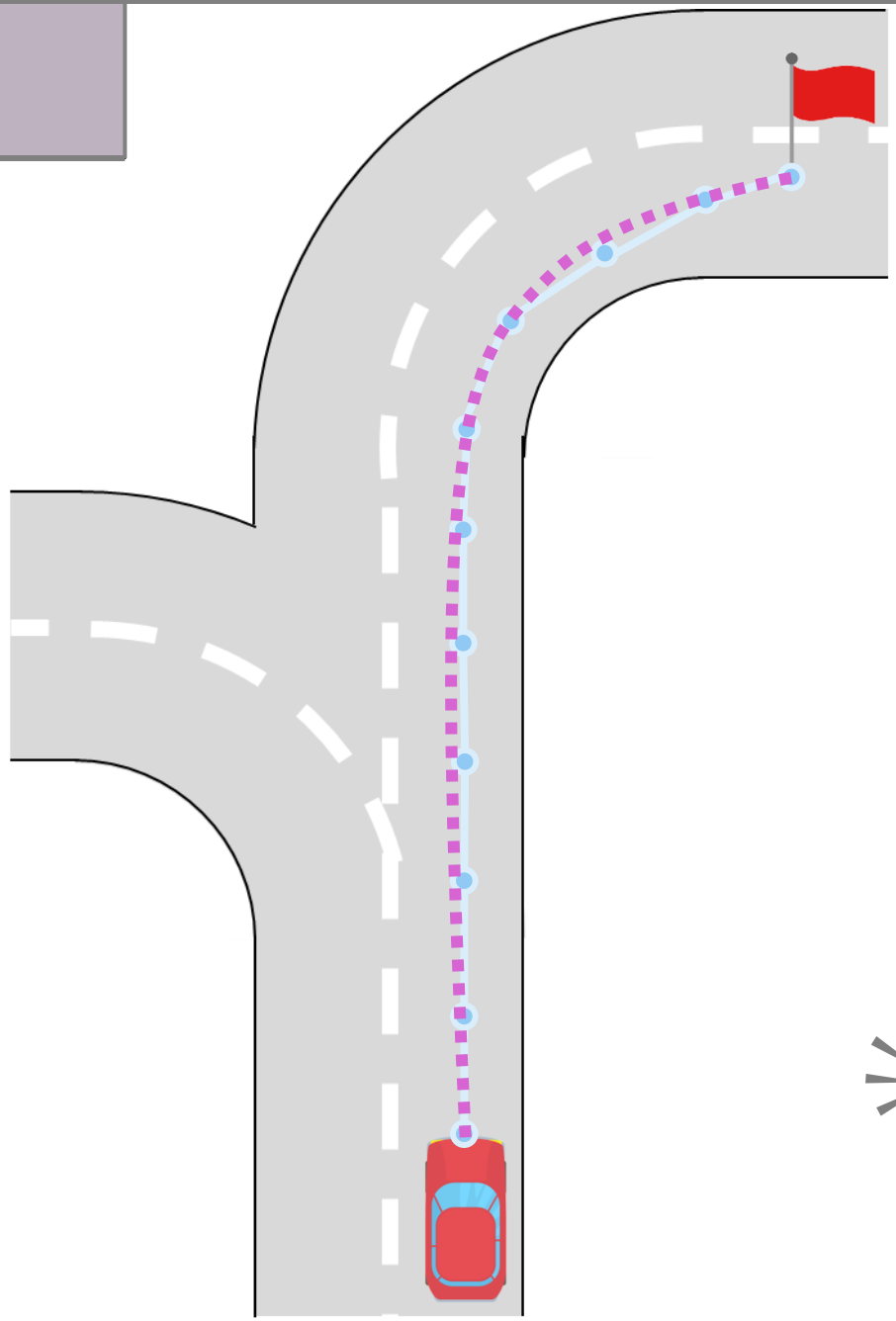

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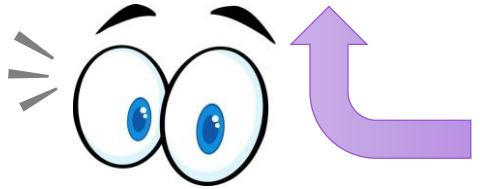

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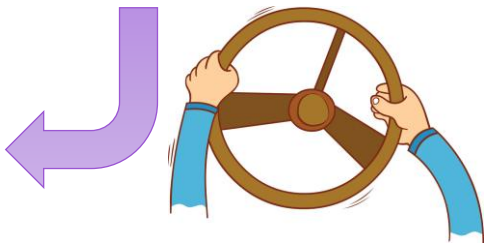

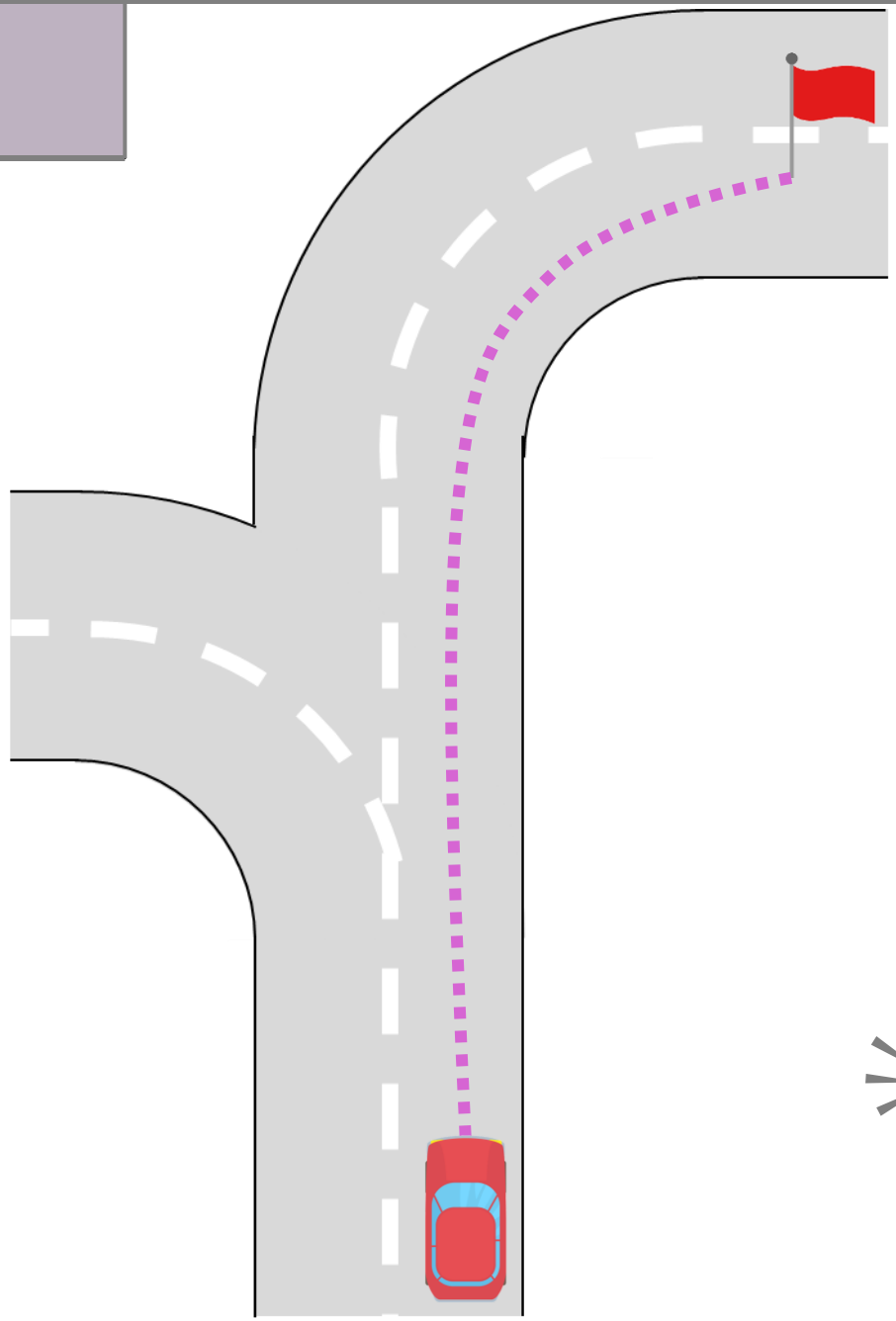

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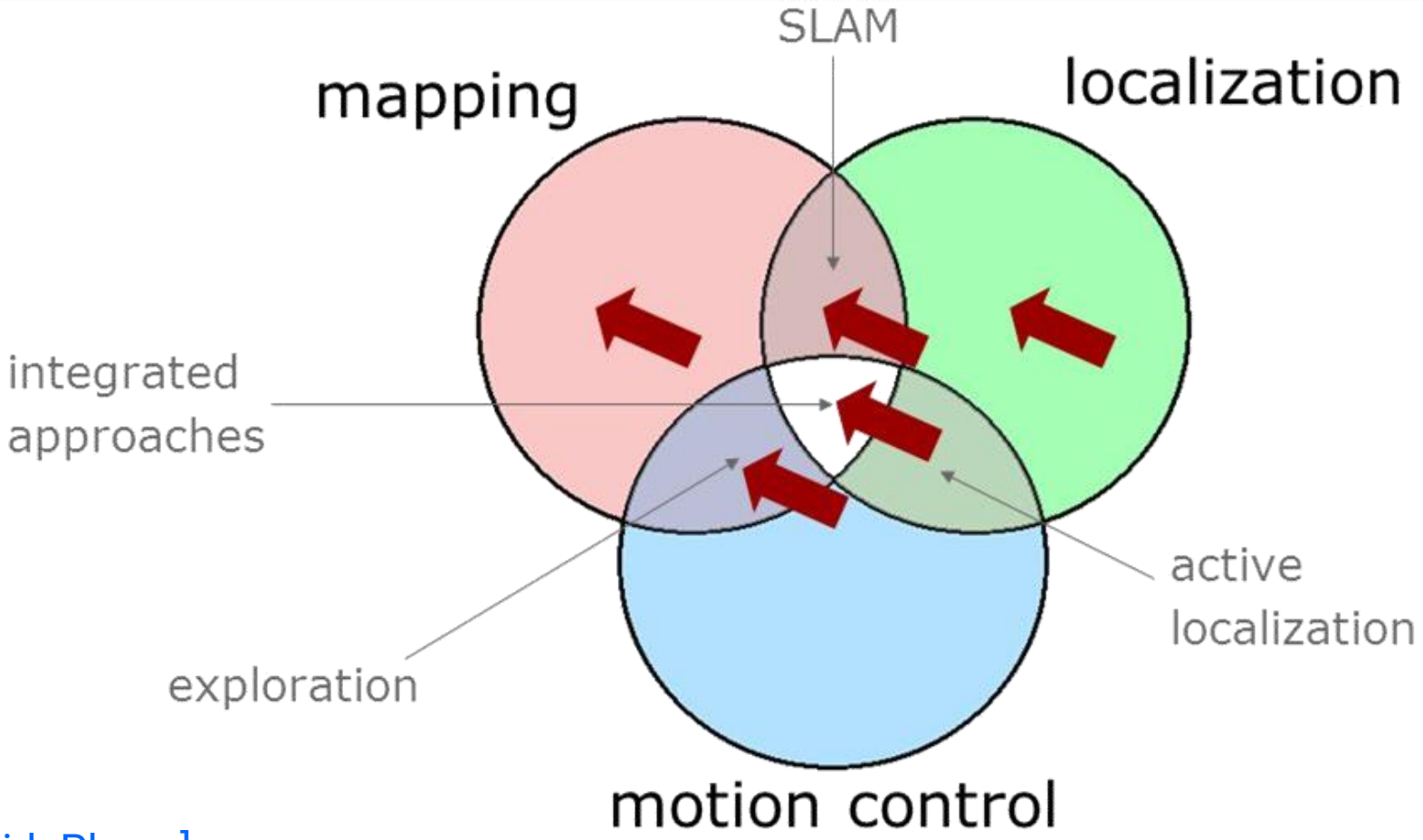
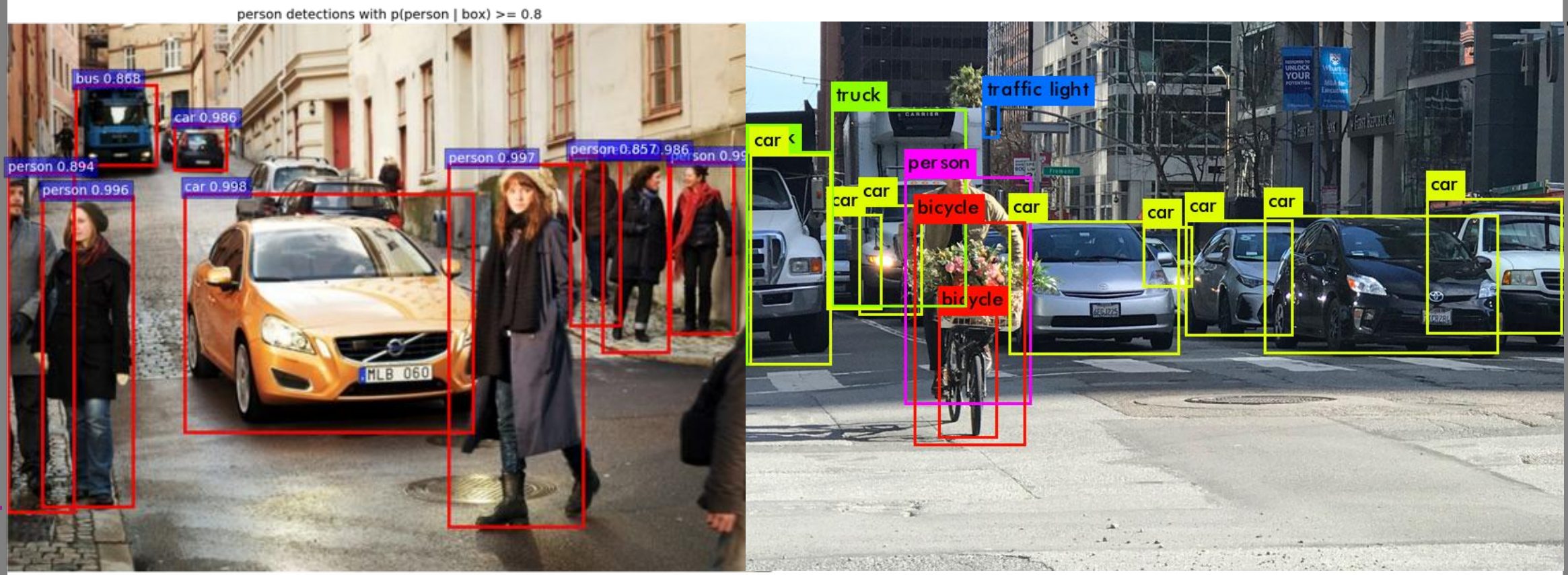
Dimensions of Mobile Robot Navigation



[SlidePlayer]
Probabilistic Techniques for Mobile Robot Navigation

Other Issues

Pedestrian/Car Detection



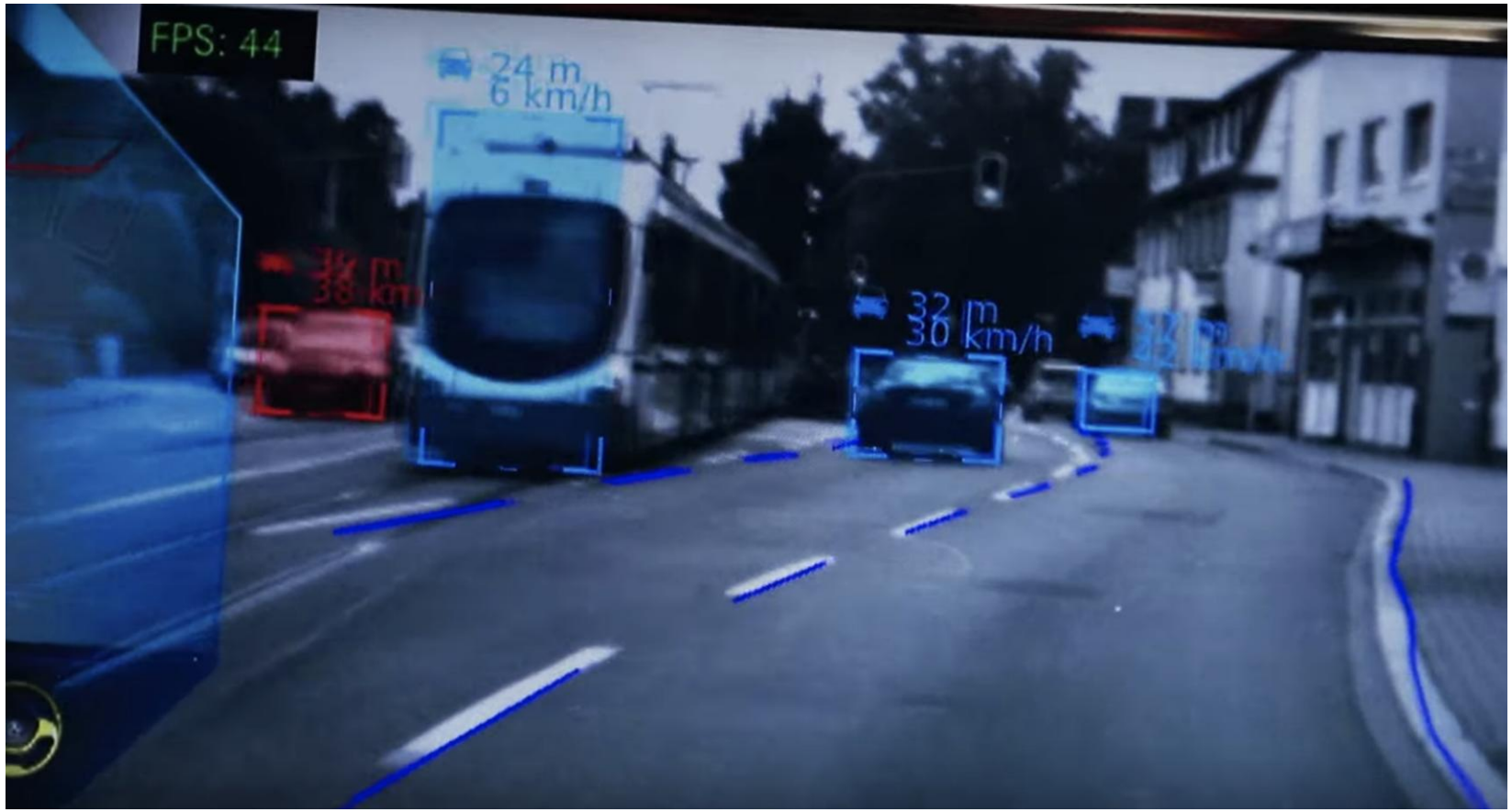
Road Lane Detection

Mercedes-Benz S 500 INTELLIGENT DRIVE | research vehicle

Traffic Light Detection & Identification

Mercedes-Benz S 500 INTELLIGENT DRIVE | research vehicle

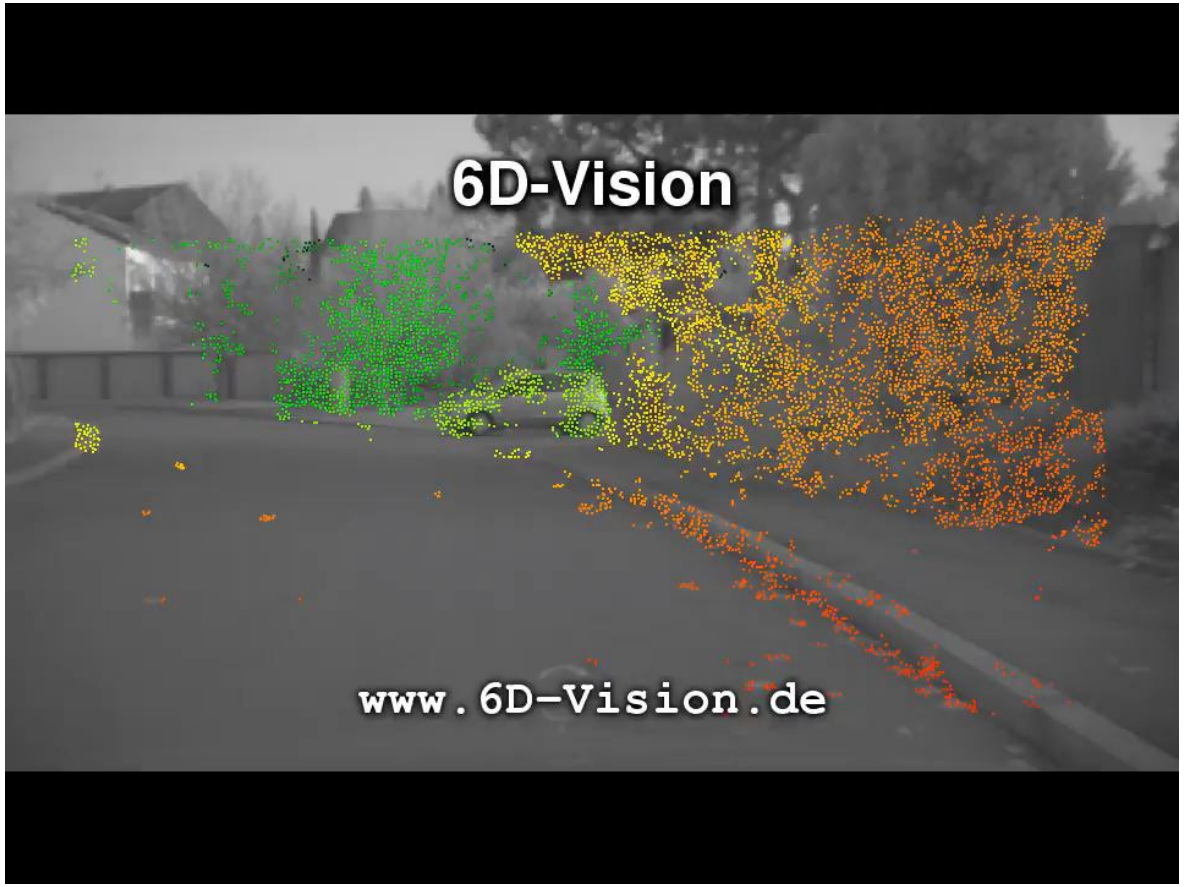
Movement Prediction



Mercedes-Benz S 500 INTELLIGENT DRIVE | research vehicle

Accident Avoiding

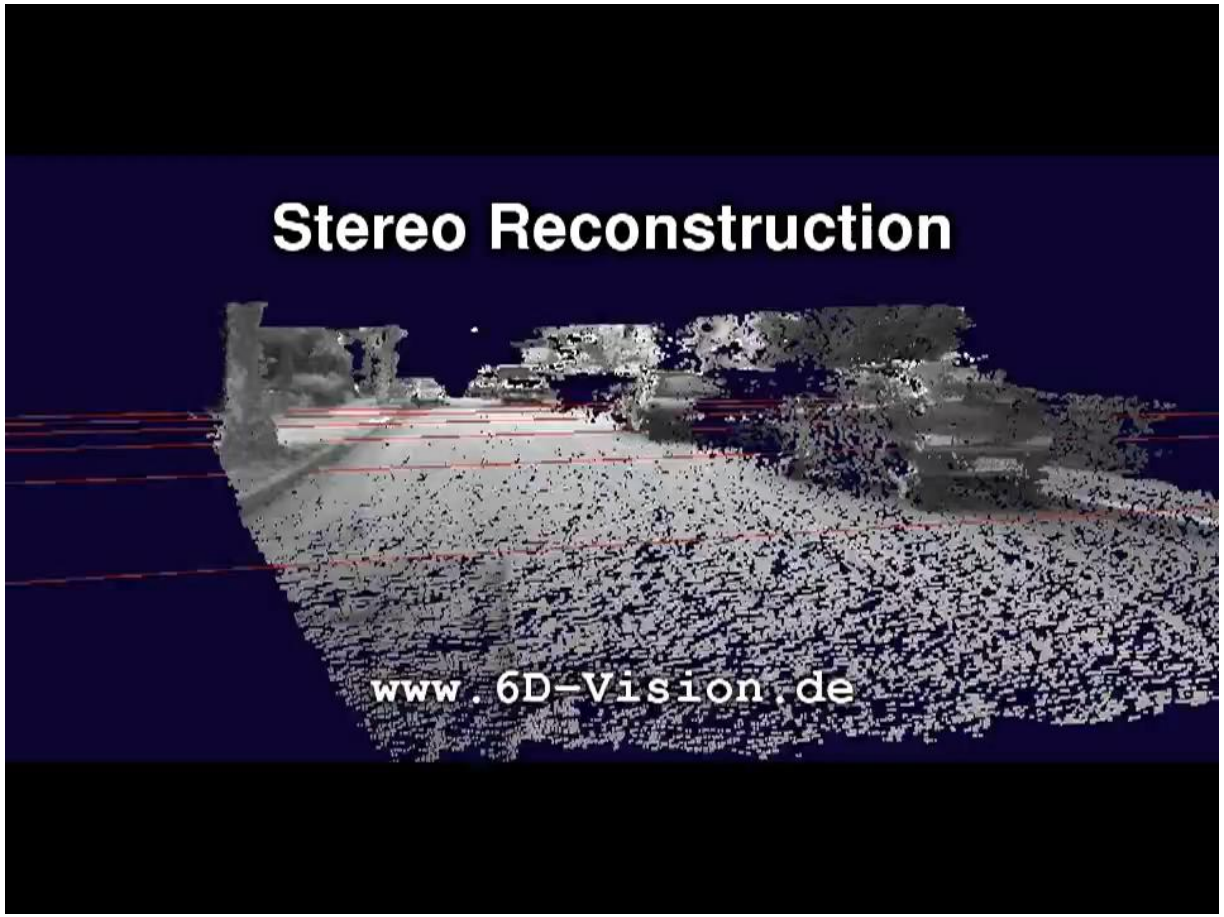
Motion Estimation



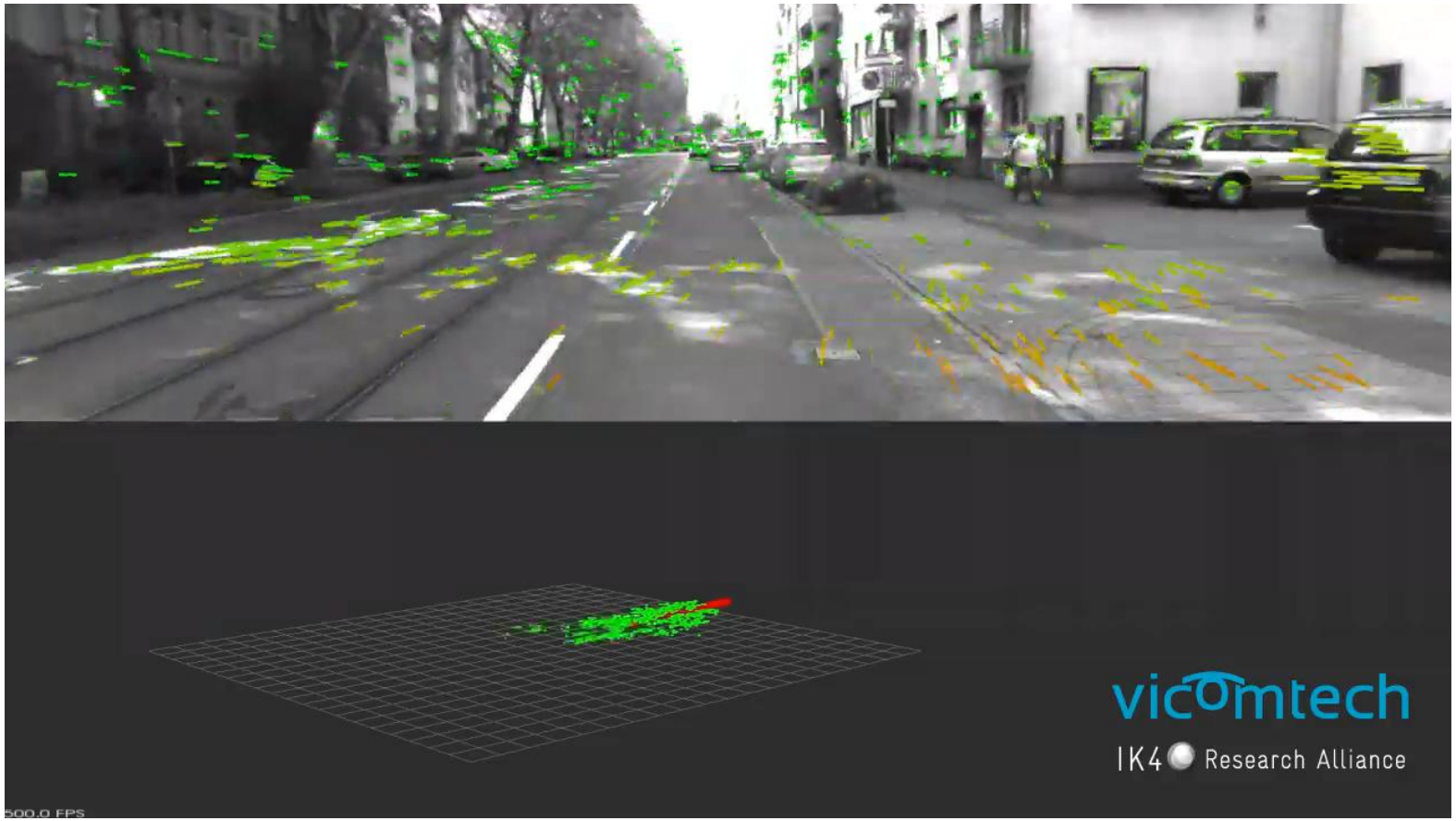
Recognize hazards faster than the human and avoid accidents especially in complex urban traffic situations.

Stereo Reconstruction

- Determines depth to almost every image point in the scene precisely



Ego-Motion Estimation (Visual Odometry)



Real-Time Stereo Visual Odometry and 3D Mapping for Autonomous Navigation
https://www.youtube.com/watch?v=ITQGTbrNssQ

Driver Status Analysis

STONKAM Vehicle Security Products

Application Scenarios

Kiva Robot (Amazon)

https://www.youtube.com/watch?v=HSA5Bq-1fU4

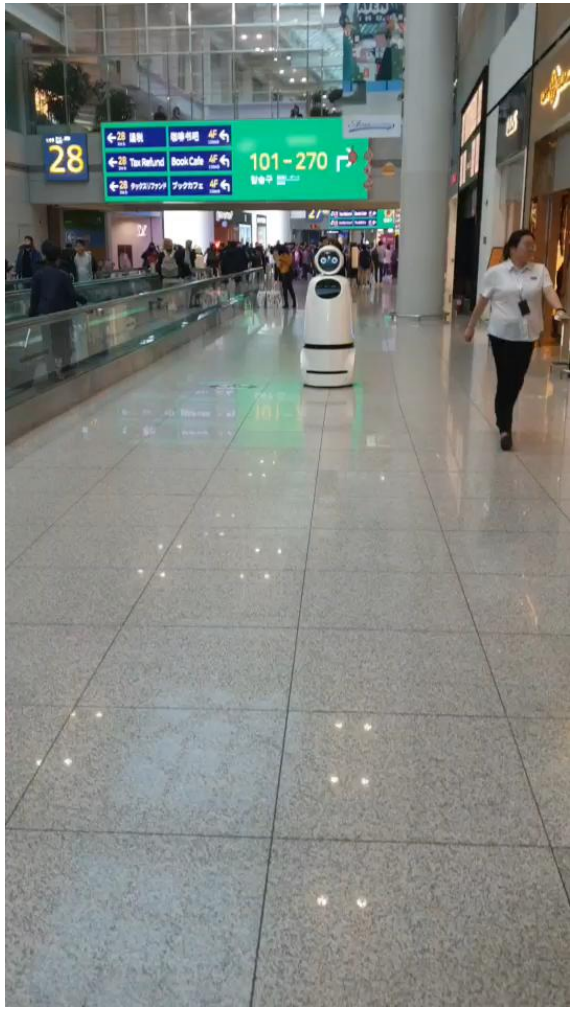
Warehouse Automation

https://alcottglobal.com/infographic/warehouse-automation-techmap-2023

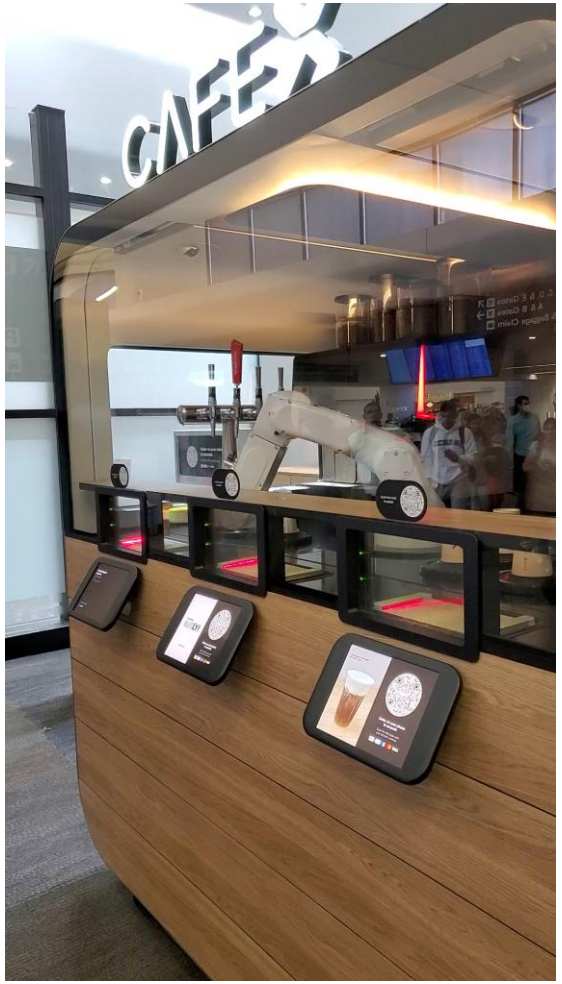
Bossa Nova's Robot (Walmart)

https://www.youtube.com/watch?v=KRJV1SPYpIE

Airport Guide Robot (Incheon)



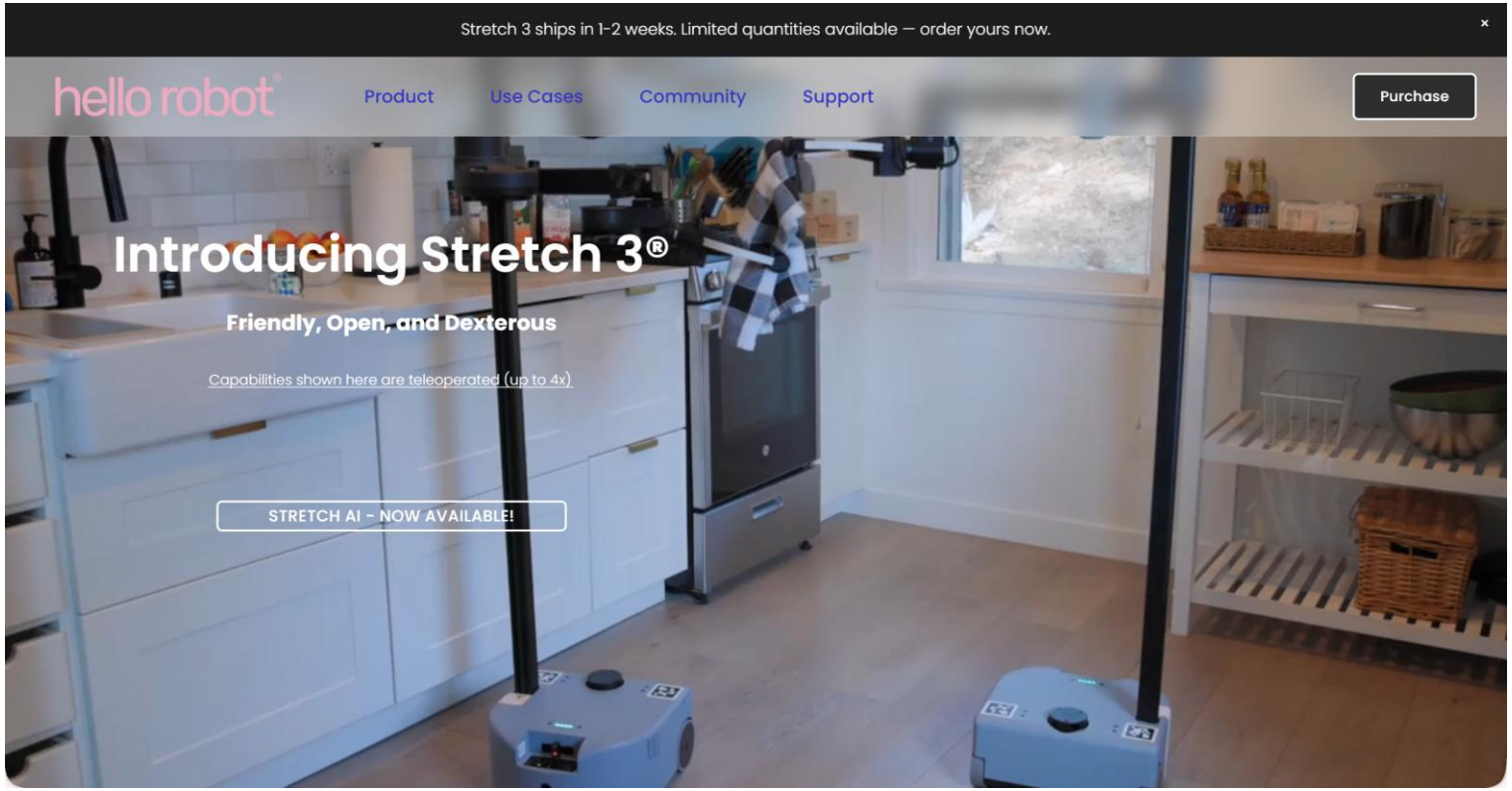
Cooking Robot/ Home Robot



Stanford robot learns from humans

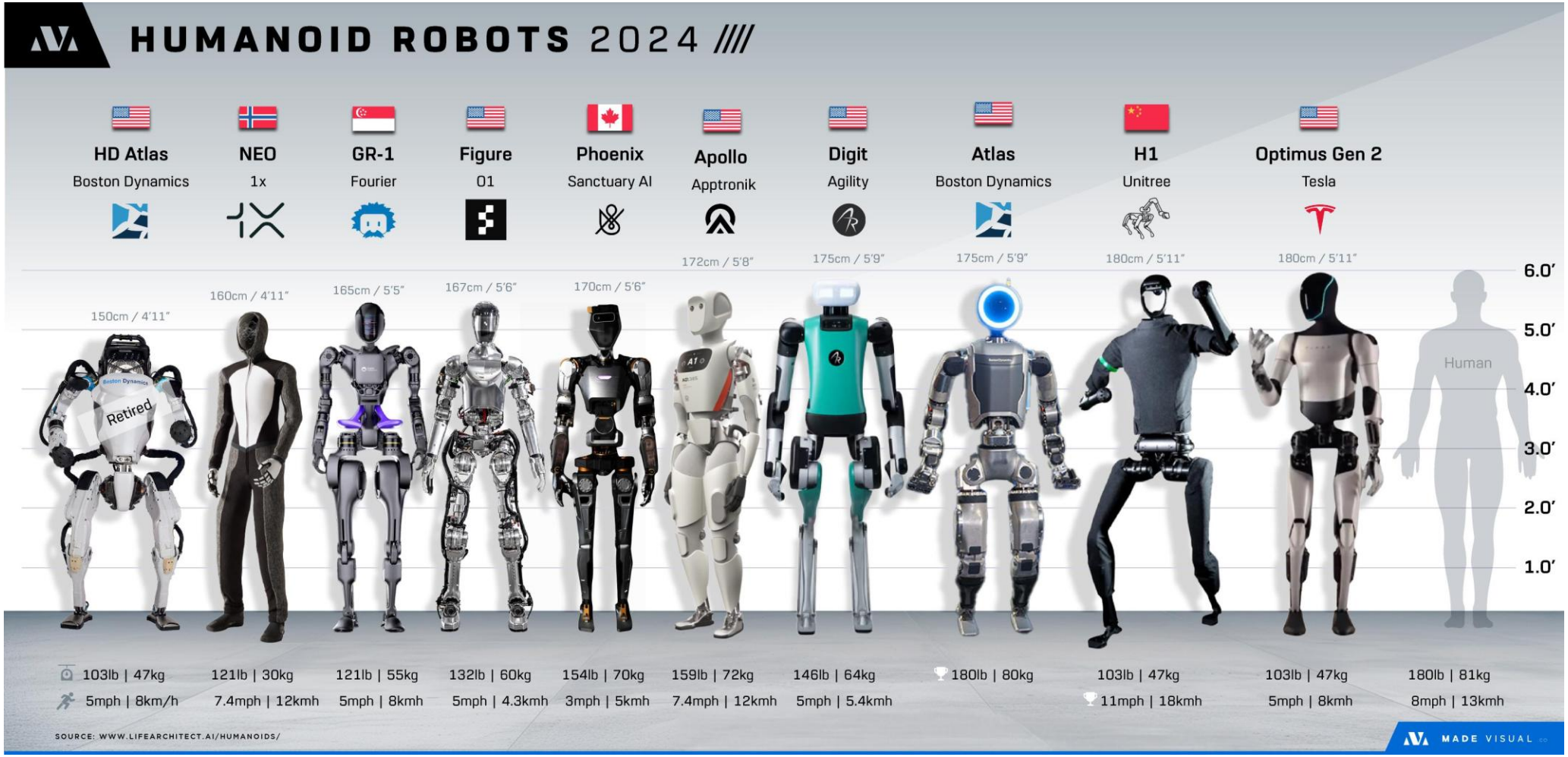
https://www.youtube.com/watch?v=P7FRO_6L-iA&t=23s

Home Robot



https://hello-robot.com/

Humanoid Robot



https://www.reddit.com/r/coolguides/comments/1c943nd/a_cool_guide_to_currentgeneration_humanoid_robots/

Any Question