AUTONOMOUS VEHICLES – PLANNING AND SYSTEM DESIGN

Course Objectives:

The objectives of this course is to

1. Provide a strong foundation of fundamental concepts in Autonomous Vehicles.
2. Design considerations and safety assessment of self-driving cars.

I. Introduction

Introduce autonomous systems and autonomous vehicles, Need for autonomy, Autonomous Vehicles – Enabling technologies, Sensors and communications, Control architecture, Challenges.

II. Discrete Motion Planning

Motion Planning from discrete problems, Graph search, Dijkstra's and A* algorithms, heuristic and non-admissible heuristic search.

III. Ground Vehicles

Systems of ordinary differential equations- The Omnidirectional Robot, The Differentially-Driven Mobile Robot, holonomic and non- holonomic systems, Dynamic Models.

IV. Motion Planning With Differential Constraints

Motion-Planning Problems, RRTs for motion planning, RRT*, Planning Using Motion Primitives and State Lattices, Decoupled Approach to Motion Planning – Examples.

V. Dynamic Optimization and Motion Planning Control

Dynamic Optimization – Background, Examples, System Dynamics, Objective Function, Constraints, Mathematical Formulation, Challenges , Direct Methods – The Overall Idea, Non-Linear Program (NLP), Automatic Differentiation – AD, Case study.

Course Outcome:

1. Understand commonly used hardware used for self-driving cars.
2. Identify the main components of the self-driving software stack.
3. Program vehicle modeling and control.
4. Analyze the safety frameworks and current industry practices for vehicle development.

Text Books

1. Introduction to SLAM Part E Chapter 46.1 in Siciliano, B., and Oussama K., eds. "Springer handbook of robotics", ISBN: 978-3-540-23957-4.
2. Autonomous Vehicles and Future Mobility by Pierluigi Coppola., " Elsevier Inc., ISBN : 978-0-12-817696-2.

Reference Books

1. Bergman, K.: "On Motion Planning Using Numerical Optimal Control", Licentiate Thesis, Div. Automatic Control, Linköping Univ., 2019.
2. Bobrow, J. E., S. Dubowsky, & J. S. Gibson: "Time-optimal control of robotic manipulators along specified paths". The International Journal of Robotics Research, 4(3), 3-17, 1985.
3. Likhachev, "Planning long dynamically feasible maneuvers for autonomous vehicles". The International Journal of Robotics Research, 28(8), 933-945, 2009.
4. "Effects of driverless vehicles-Comparing simulations to get a broader picture" A. Pernestål et al. European Journal of Transport & Infrastructure Research 19.1 (2019).