Course Presentation

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Lecture 0 – Monday September 18, 2016

Outline

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Course Description

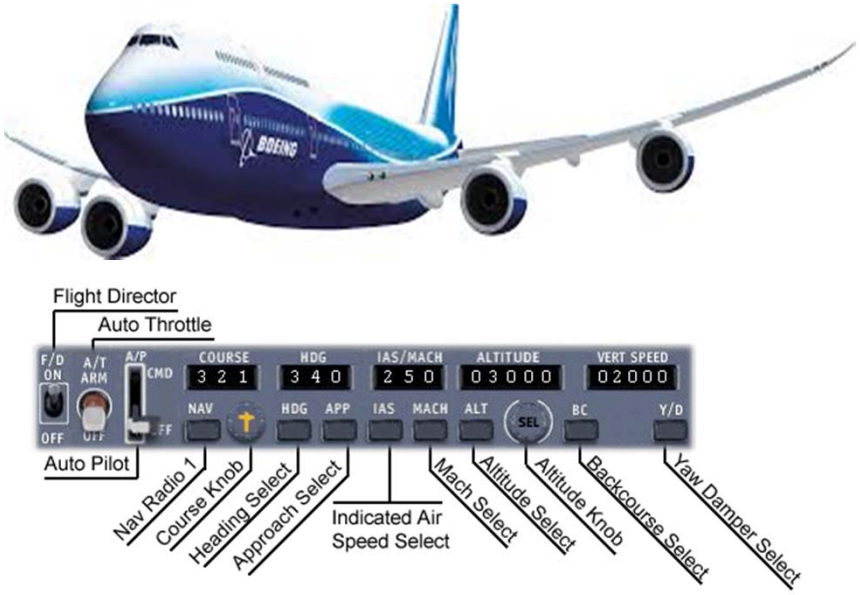
Autonomous vehicles are **intelligent vehicles** that can perform desired tasks in **unstructured environments** without continuous **explicit** human guidance.

Mobile robots are commonly used as a **platform** to study different aspects of autonomous systems. These aspects include, but are not limited to, **environment mapping, localization, motion planning, navigation, decision making under uncertainty, learning, and interaction with human or non-human actors** in the environment.

Autonomous Vehicles Design and Control course aims at providing students with the basics required to develop **autonomous vehicles**.

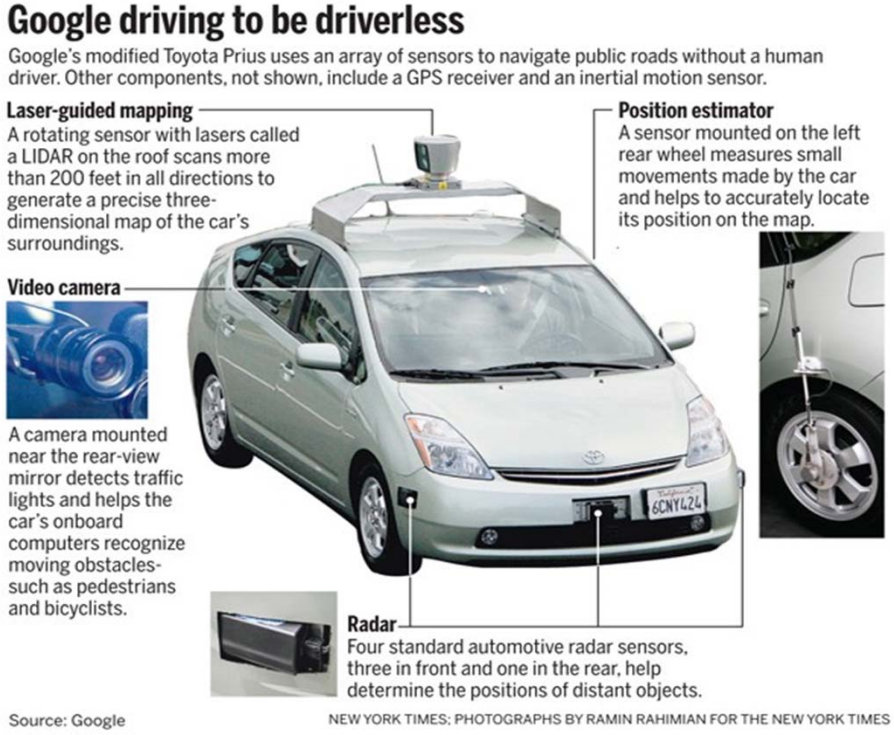
Course Description

- **Why is difficult to build autonomous vehicles?**



The first aircraft autopilot was developed in **1912**

Structured Observable Static Environment



logged nearly 1.1 million km autonomous driving by April **2014**. 100% autonomous in May 2014

Unstructured, Dynamic and Partially Observable Environment

Course Description

- **Q1:** Where am I? Where am I going?
- **A1:** Localization
- **Q2:** What does the world look like?
- **A2:** Environment Mapping or Modeling
- **Q3:** How to explore an unknown environment?
- **A3:** Simultaneous Localization and Mapping “SLAM”
- **Q4:** How can I get there from here?
- **A4:** Motion Planning
- **Q5:** How to achieve intelligent connection between perception and action?
- **A5:** Control Architecture

Course Topics

- Introduction to Autonomous Vehicles
- Locomotion Systems
- Sensing and Perception
- Localization
- State Estimation
- Environment Mapping
- Discrete Motion Planning
- Combinatorial Planning
- Planning under Uncertainty
- Learning

Course Policy

Evaluation Method	Weight
Assignments	10% (2.5X4 assignments)
Midterm Report	10%
Midterm	25%
Project	20%
Final Exam	35%
Total	100%

Course Project

Projects can be done individually but preferably in group of **maximum 4 students**. Students will be requested to select one of the following project types:

- Type A: Autonomous Vehicle Design and Implementation
- Type B: Empirical Evaluation
- Type C: Algorithm Design

Course Project

Type A: Autonomous Vehicle Design and Implementation

- Students identify a problem in a pertinent area of academic, industrial or commercial importance for which there are no available autonomous vehicle with reasonable cost and capabilities. This vehicle must contain a combination of mechanical, electronic, computer and control components integrated together in order to solve the problem at hand.
- Design and develop an autonomous vehicle to solve this problem.
- Students have to use Robot Operating System (ROS) to develop all the software modules of the vehicle. They can develop the algorithms from scratch or use available open-source modules.
- Analyze experimentally the performance of the developed vehicle.

Course Project

Type B: Empirical Evaluation

- In this type of projects, student will pick an autonomous vehicle problem that interests him/her such as autonomous navigation, simultaneous localization and mapping, adaptive planning, etc.
- Student is supposed to search the literature for approaches to tackle this problem, identifies strong and weak points of each approach and selects the most appropriate approach.
- He/she must implement and experiment with the selected technique to quantitatively evaluate its performance in tackling the problem.
- All the implementation must be ROS-compatible.

Course Project

Type C: Algorithm Design

- Student identifies an autonomous vehicle problem for which there are no satisfying approaches such as cooperative SLAM, cooperative motion planning of autonomous vehicles, UAVs communication relaying, group formation of unmanned vehicles, etc.
- Develop a new technique to tackle this problem.
- Analyze theoretically and/or empirically the performance of his/her technique.
- All the implementation must be ROS-compatible.

Course Project

- **Project Paper**

  The result of the course project will be a scientific paper (6-pages) along with the source code developed to solve a given problem. IEEE Manuscript Template must be used. This paper MUST contain the following sections:

  - Abstract
  - I. Introduction
  - II. Related Work
  - III. Problem Formulation and Modeling
  - IV. Proposed Approach
  - V. Performance Evaluation
  - VI. Conclusion
  - References

Course Resources

- **Course Website**

  http://www.alaakhamis.org/teaching/AVDC2016/index.html

- **Textbook**
  - R. Siegwart and I. Nourbakhsh . *Introduction to Autonomous Mobile Robots*. MIT Press, 2004.
  - Thomas Braunl. *Embedded Robotics*. Springer, 2006.
  - Phillip McKerrow. *Introduction to Robotics*. Addison-Wesley, 1991.
  - Mark Lee. *Intelligent Robotics*. Halsted Press and Open University Press, 1989.

Course Resources

- **Course Instructor**

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  Office: Adjunct Professors Room

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- **Course TAs**

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Questions?