Autonomous Vehicles

House Transportation Policy Committee

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Introduction

- Full-Time Assistant Professor of Electrical Engineering and Renewable Energy at Oregon Institute of Technology (Oregon Tech).

- Specialty Director for Oregon Tech’s Masters of Engineering, Embedded Systems Specialization. Currently designing the MSE program to work with graduate students on embedded systems and autonomous vehicles.

- Course and areas of technical expertise include advanced digital design, microcontrollers/microprocessors, and embedded systems.

- MSEE, Oregon State University, 1993.

Introduction

- 24 years of industry experience in digital design focused on embedded systems and digital video processing.

- Founded two custom design and consulting firms.

- Currently working as a Lead Design Engineer and Engineering Manager developing products for remote sensing in airborne applications.
  - Visual and infrared camera systems (SWIR, MWIR, LWIR)
  - Image Processing
  - Laser Range Finders
  - GPS

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Oregon Tech

- Oregon Tech's Electrical Engineering and Renewable Engineering (EERE) and Computer Systems Engineering (CSE) departments specialize in embedded systems. This is the core technology enabling autonomous vehicles.

- The EERE Department is currently partnering Kerr Avionics to develop an embedded system using infrared cameras to assist aircraft landing in foggy environments. This project is funded by Oregon BEST.

- The goal of Oregon Tech's Master's in Engineering Program as well as undergraduate capstones and industry-supported projects is to deliver highly-trained, capable graduates to meet the growing needs of industry.

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Suggested Topics

- House Transportation Policy desires to:
  1. Understand how the technology works
  2. Understand issues in order to build an effective policy for the use of autonomous vehicles in Oregon.

General Types of Computers

- Personal Computers (PCs) are possibly the best known form of computing. Personal computers emphasize delivery of good performance to single users, low cost, and execute a wide variety of third-party software.
- Servers are the modern form of what were once much larger computers, and are usually accessed only via a network. Servers are oriented to carrying large workloads, which may consist of either single complex applications handling many small jobs, such as would occur in building a large web server.
- Embedded Computers are the largest class of computers and span the widest range of applications and performance. They are "embedded" within larger systems, interface with a specific set of sensors/actuators, and typical perform a very specific set of functions with application specific software.

- Embedded Application Examples
  - Modern Automobiles
  - Smart TVs and Blue ray Players
  - Networked processors that control a modern airplanes and ships
  - Autopilot Systems
  - Industrial Automation
  - Internet of Things (IoT)
  - Autonomous Vehicles

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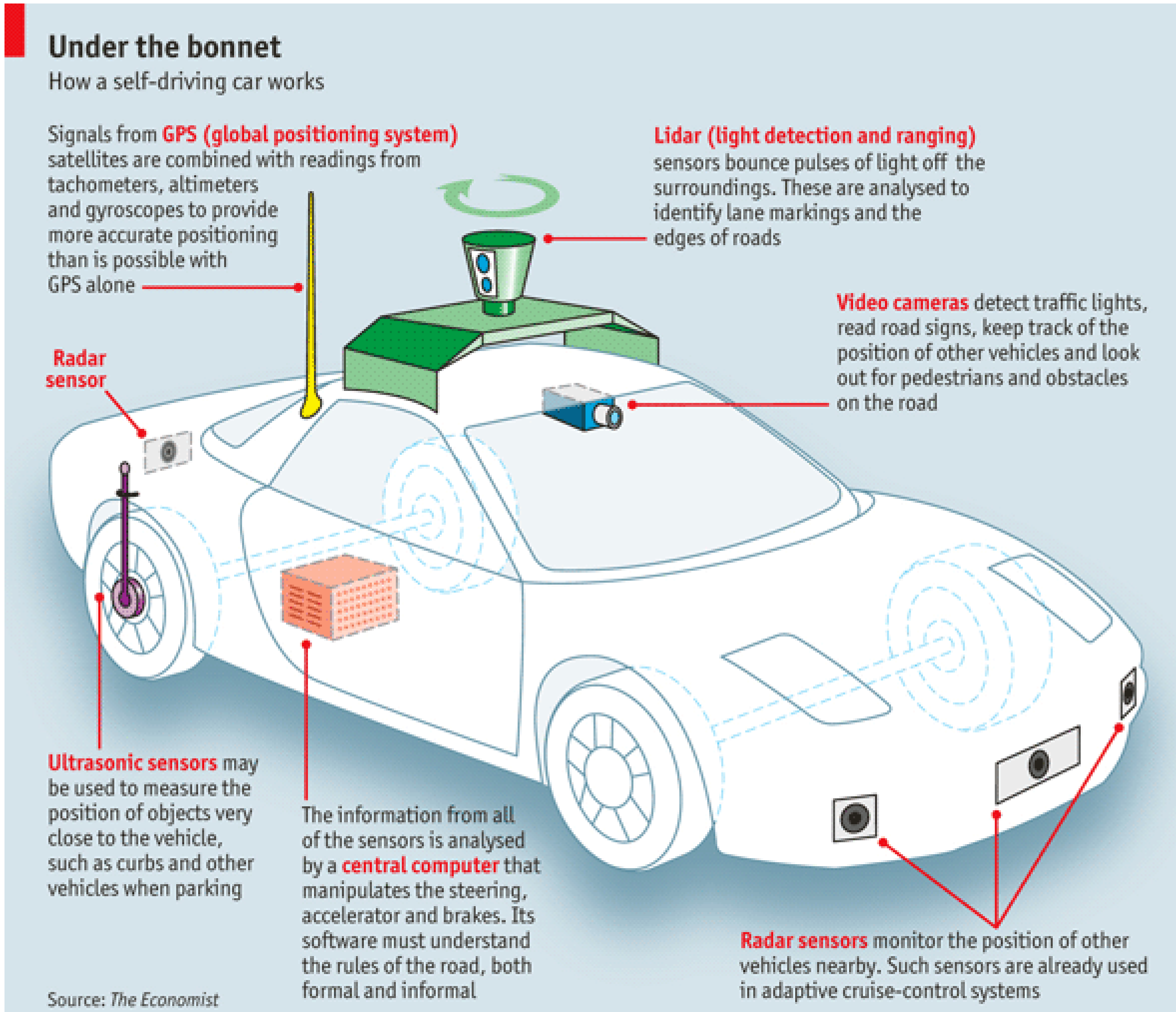
Embedded Systems Challenges

- Multidisciplinary industry (hardware, networking (IT), real-time software, software analytics, data-driven decisions)
- Applications require many different devices, sensors, actuators and software protocols and, generally, there is a lack of standards.
- Rugged (Temperature, Shock, Vibration)
- Reliable (Very high MTBF)
- Small Footprint
- Real-Time Processing
- Network Connectivity
- Remote Upgradability (Firmware and Software)
- Integrated Security/Data Privacy (Hardware and Software)
- Secure Boot/Encryption/Authentication

Anatomy of Autonomous Car



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SAE Automated Vehicle Classifications

- Level 0: Automated system issues warnings but has no vehicle control.
- Level 1 (”hands on”): Driver and automated system shares control over the vehicle. An example would be Adaptive Cruise Control (ACC) where the driver controls steering and the automated system controls speed. Using Parking Assistance, steering is automated while speed is manual. The driver must be ready to retake full control at any time. Lane Keeping Assistance (LKA) Type II is a further example of level 1 self driving.
- Level 2 (”hands off”): The automated system takes full control of the vehicle (accelerating, braking, and steering). The driver must monitor the driving and be prepared to immediately intervene at any time if the automated system fails to respond properly.
- Level 3 (”eyes off”): The driver can safely turn their attention away from the driving tasks. The vehicle will handle situations that call for an immediate response, like emergency braking. The driver must still be prepared to intervene within some limited time, specified by the manufacturer, when called upon by the vehicle to do so.
- Level 4 (”mind off”): As level 3, but no driver attention is ever required for safety. Self driving is supported only in limited areas (geofenced) or under special circumstances, like traffic jams. Outside of these areas or circumstances, the vehicle must be able to safely abort the trip.
- Level 5 (”wheel optional”): No human intervention is required.

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Autonomous Vehicle Technical Challenges

- Technical Challenges
  - Navigation via GPS with traffic/congestion information
  - Very High Sensor Bandwidth (cameras, radar, LIDAR)
  - Vehicle speed, direction control, and diagnostics
- Difficult Technical Challenges
  - Sensing of traffic boundaries (stationary objects)
    - Maintaining lane position
    - Following traffic signs and navigation of construction zones
    - Avoiding road debris
  - Operation in Non-Ideal Weather Conditions
  - Enhanced Network Security
- Very Difficult Technical Challenges (Research)
  - Machine Learning and Pattern Recognition (artificial intelligence)
    - Convolutional Neural Networks (CNN) require training
  - Advanced Computational Hardware and Software Applications
    - Graphics Processing
    - Rapid Object Recognition
    - Moving Object Avoidance
    - Rapid (Ethical) Decisions to minimize Damage or Loss of Life

Evolution and Adoption

- Advanced System Examples
  - Adaptive Cruise Control
  - Collision Avoidance Systems (Radar, LIDAR, image recognition)
  - Automatic Parking
  - Lane Departure Warning Systems (Video, Laser, IR Sensors)

  - Once the technology is proven, it typically takes ~10 years to reach maturity in the market.

- Over the next 5-10 years, we will see more features and capabilities (SAE Level 2/3/4) which are essentially Advanced Driver Assist features.

Evolution and Adoption

- The automotive industry is push technology aggressively.

- Daimler, one of the largest vehicle manufacturers in the world, announced that it is partnering with Bosch, one of the largest automotive tech and hardware suppliers in the world, to bring fully autonomous vehicles to urban roads "by the start of the next decade."

- Mercedes-Benz Cars R&D validation and testing, Jochen Haab, said in an interview March, 2017 that a "driverless taxi"-type situation was "at least a decade away."

- Truly autonomous vehicles (SAE Level 5) will require a huge investment and a leaps in technology. If this trend continues, we will see Level 5 vehicles by 2030.