Business Applications of Machine Learning

Professor Kartik Hosanagar

Autonomous Vehicles (AVs)

- Intro to autonomous vehicles & market overview
- How AVs work (sensors, connectivity & AI in the car)

What are Autonomous Vehicles (AVs)?

- "An autonomous vehicle, also known as a driverless vehicle, is a vehicle that can move and guide itself without human input." Autonomous vehicles exist on a spectrum
  - Some have specific autonomous functions that assist human drivers
  - Others don't require or even allow human intervention

Content/quotes from: https://marketbusinessnews.com/financial-glossary/autonomous-vehicle/
Additional content from: https://advi.org.au/driverless-technology/

Wharton
University of Pennsylvania

Levels of Automation

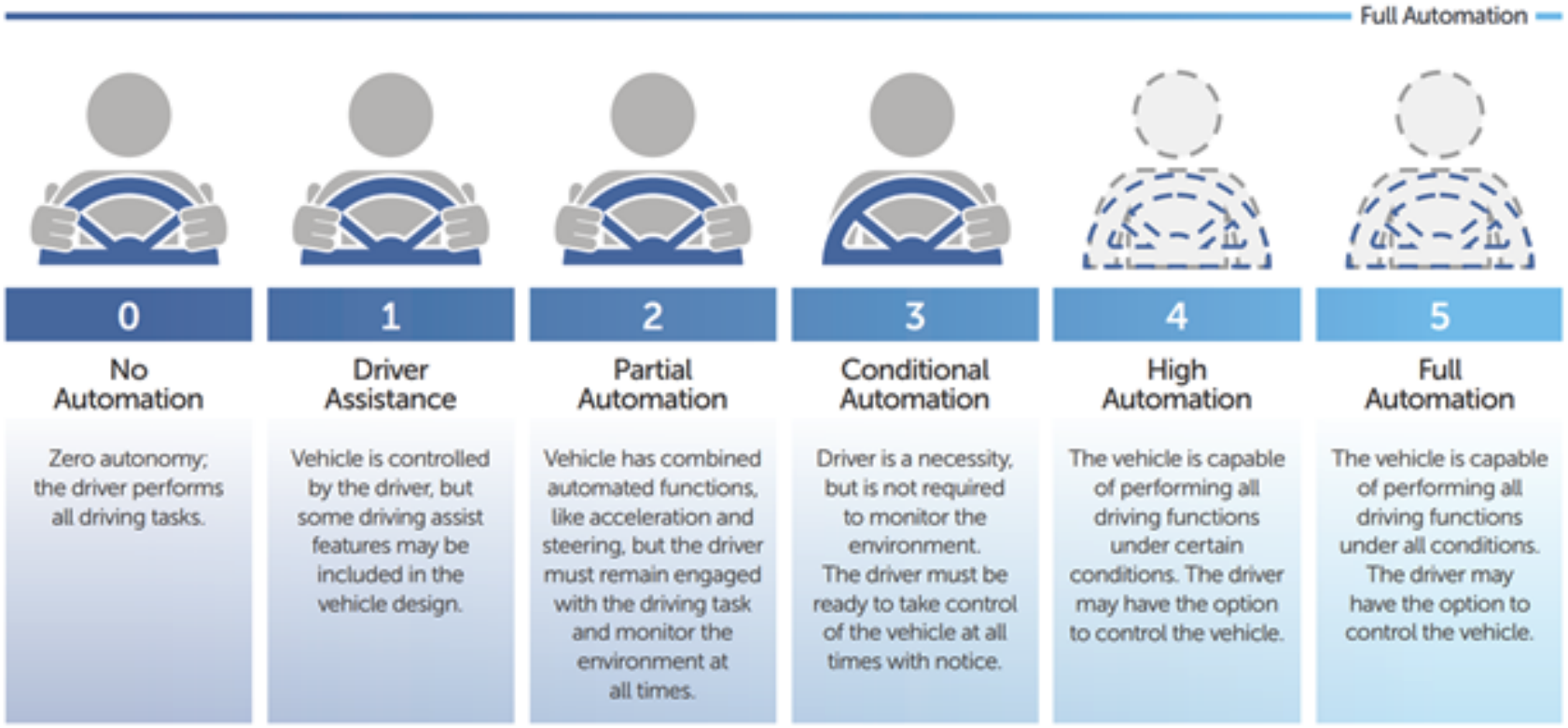


Image: https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/13069a-ads2.0_090617_v9a_tag.pdf

Overview of the Autonomous Vehicle Market

Driving Factors

94% of accidents currently caused by human error

Efficiency

- $1.3 trillion in potential saving in U.S. per year
- $158 billion savings in fuel
- $507 billion in productivity increases
- $488 billion reduction in annual accident costs

Current Players

WAYMO

BMW

VOLVO

TESLA

NISSAN

Mercedes-Benz

These market pull factors have drawn many players into a space that is projected to take off by 2030.

Wharton
University of Pennsylvania

How do Autonomous Vehicles Work?

3 core technologies enable driverless cars:

Sensors

Sense surroundings through:

- Lidar
- Cameras
- GPS Antennas
- Radars, etc.

Connectivity

Access to:

- Traffic
- Weather
- Adjacent Cars
- Maps, etc.

Control Algorithms

Capture data from sensors & connectivity to make decisions on

- Steering
- Braking
- Speed, etc.

Wharton
University of Pennsylvania

Content/quotes from: https://www.fi.edu/science-of-selfdriving-cars

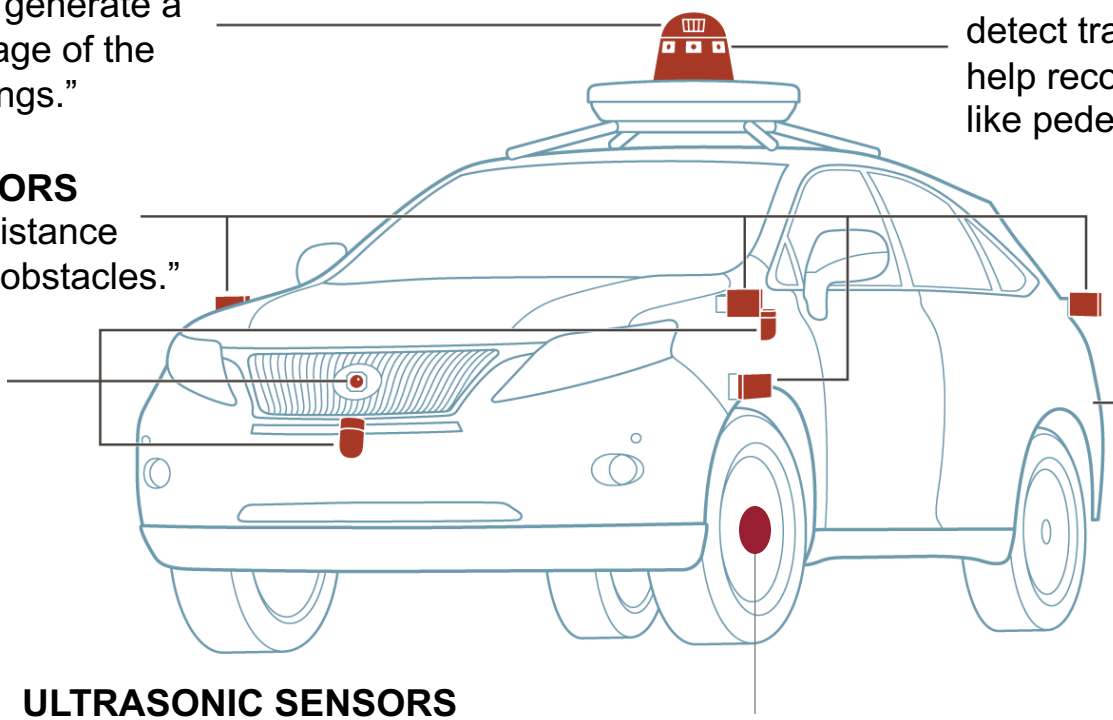
Sensors, Computers and their Functions

LIDAR UNIT
"Constantly spinning, it uses laser beams to generate a 360-degree image of the car's surroundings."

CAMERAS
"Uses parallax from multiple images to find the distance to various objects. Cameras also detect traffic lights & signs, and help recognize moving objects like pedestrians & bicyclists."

RADAR SENSORS
"Measure the distance from the car to obstacles."

ADDITIONAL LIDAR UNITS



MAIN COMPUTER (IN TRUNK)
"Analyzes data from the sensors, and compares its store maps to assess current conditions."

ULTRASONIC SENSORS
"May be used to measure the position of objects very close to the vehicle, such as curbs and other vehicles when parking."

Image and content from: https://www.nytimes.com/2018/03/19/technology/how-driverless-cars-work.html
The part on ultrasonic sensors was added in based on a similar diagram from The Economist. That diagram can also be found at: https://medium.com/@jonathan_hui/self-driving-car-path-planning-to-maneuver-the-traffic-ac63f5a620e2

Wharton
University of Pennsylvania

Control Algorithms: AI in the Car

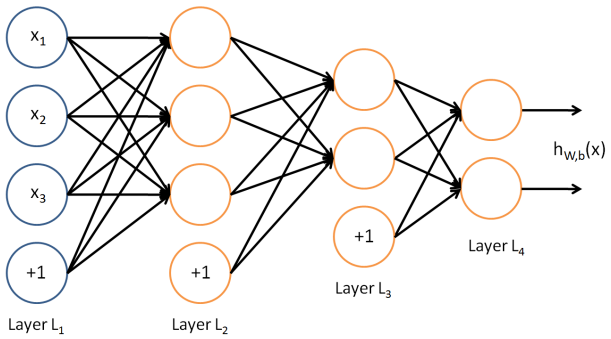
- Sensors and connectivity allow data to be gathered about the driving environment, but an autonomous vehicle requires AI for the vehicle to actually "understand how to see, understand what it's seeing, and make the right decisions in any imaginable traffic situation."
- How do autonomous vehicles learn to drive?
  - Machine learning is particularly important because humans cannot describe every aspect of how they drive, so a rule-based approach would not be sufficient to develop autonomous vehicles. AVs learn to drive by observing how human drivers drive
  - Training data: Cars with sensors are driven by humans so that data about driving patterns can be gathered, and then this data is fed back to the model
  - Deep learning (neural networks) algorithms are commonly used as part of the motion planning system

Content/quotes from: https://in.micron.com/insight/on-the-road-to-full-autonomy
Additional content from: "Driverless: Intelligent Cars and the Road Ahead" by Hod Lipson and Melba Kurman and https://www.techradar.com/news/self-driving-cars

Deep Learning Neural Networks for AVs

- Deep learning neural networks are neural networks with many layers

Neural Networks Recap from Module 2



What happens in a neural network (NN)?

- Input data is provided (e.g. images), the NN detects patterns (hidden from us in the middle layers), and then outputs what the image was.
- NN learns by randomly initializing weights, evaluating & then learning the weights that improve model performance

- Deep learning neural networks allow AVs to identify images by their features, much the same way children learn.
  - A child who is shown many images of cats will ultimately recognize cats by their features and can recognize a cat even in an unfamiliar setting.
  - Cars also need to recognize familiar objects (stop sign, traffic light, pedestrian, etc.) in a variety of unfamiliar settings.

Wharton
University of Pennsylvania

Content/quotes from: “Driverless: Intelligent Cars and the Road Ahead” by Hod Lipson and Melba Kurman

Adoption of Autonomous Vehicles (AVs)

- Challenges to adoption
- Ownership models

Challenges to Autonomous Vehicle Adoption

- AV technology is rapidly improving
- AVs have great potential to make the roads safer by reducing human error, but legal, security & economic concerns instill uncertainty into their adoption.
- Many new questions must be navigated, particularly in 3 broad areas:

Legal

- Questions about liability and acceptable behavior

Security

- Questions of safety and privacy

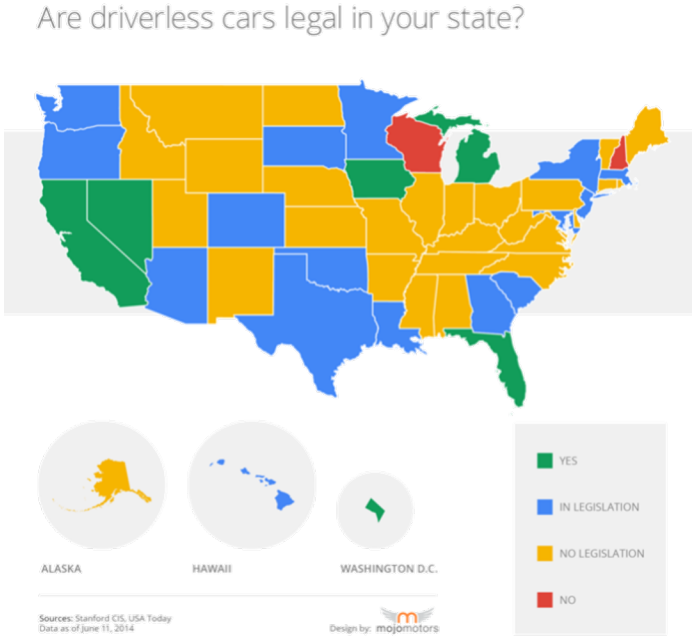
Economic

- Effects on other industries (oil, transportation, insurance)

Wharton
University of Pennsylvania

Legal Issues in AV Adoption

- Globally, there are significant differences in terms of legality of using AVs (In US, there is significant differences across states)
- Many other legal issues beyond the binary legal/illegal decision, such as:
- **Liability**
  - How will fault be assigned after accidents? Is the driver, AI developer, or car manufacturer at fault?
- **Behavior**
  - How should behavior in the car be regulated? OK to take hands off the wheel? Browse social media? Instruct the car to speed?



Content/quotes from: https://www.americanbar.org/news/abanews/publications/youraba/2018/december-2018/legal-implications-of-driverless-cars/

Security Issues in AV Adoption

- Safety and privacy concerns may be seen in AVs that aren't seen in human-driven cars, due to the presence of AI in AVs.
- **Potential safety concerns**
  - Hacking of driverless cars
    - Locking someone in a car, intentionally causing accidents, directing the car to an incorrect destination, and more.
- **Potential privacy concerns**
  - Many of the same concerns as location tracking
    - Tracking of where you've been and when, and the privacy of this data

Content/quotes from: https://foundershield.com/insurance-for-autonomous-vehicles-self-driving-cars/

Economic Issues in AV Adoption

- Many additional industries will be affected, 3 examples include:
- **Oil & Gas**
  - AVs could increase energy consumption by making it easier to travel by car.
  - Could still reduce demand for gas if AVs tend to be electric.
  - Oil & gas companies will need to create a new place for themselves.
- **Driving jobs**
  - About 3.5 mil. truck drivers & 200,000 taxi drivers/chauffeurs in the U.S.
  - AVs likely to reduce demand for drivers.
  - Taxi/trucking companies may move towards managing fleets of AVs.
- **Insurance**
  - As AVs make driving safer, demand for traditional insurance plans may change.
  - Usage-based insurance policies that charge by miles driven and driving habits may become more common.
  - Liability policies will need to change

Content/quotes from: https://www.cbinsights.com/research/13-industries-disrupted-driverless-cars/
Stat for # of truck drivers from: http://www.alltrucking.com/faq/truck-drivers-in-the-usa/
Stat for # of taxi drivers/ chauffeurs from: https://www.statista.com/statistics/943496/number-of-taxi-drivers-united-states/

Wharton
University of Pennsylvania

What Could Adoption Look Like?

- Two possible models of autonomous vehicle ownership:

Individual Ownership

- Individual buys vehicle
- Vehicle is mostly parked (driven ~5% of its lifetime)
- Vehicle may be rented out to others through P2P car share
- More probable in early stages of full autonomous vehicles (as a luxury amenity)

Corporate Ownership

- Corporation buys a fleet of autonomous vehicles
- Consumers “rent” vehicles on per-ride basis similar to Uber
- Ideal for cities but less profitable for less dense geographies

Wharton
University of Pennsylvania

Could a Car Become a Platform?

- What if a car did more than move people from A to B?
- Could drive adoption of complementary technologies
  - Vehicle-to-Vehicle and Vehicle-to-Infrastructure Technologies (networked automation)
  - In-Vehicle Infotainment Systems
  - Electric Cars
- Think of a car as a *platform*:
  - Content hub
  - Providing transportation for others
  - And more
- Who would make the money from this?
  - Whoever controls the software platform
  - P2P economy: Whoever owns the vehicle

Wharton
University of Pennsylvania

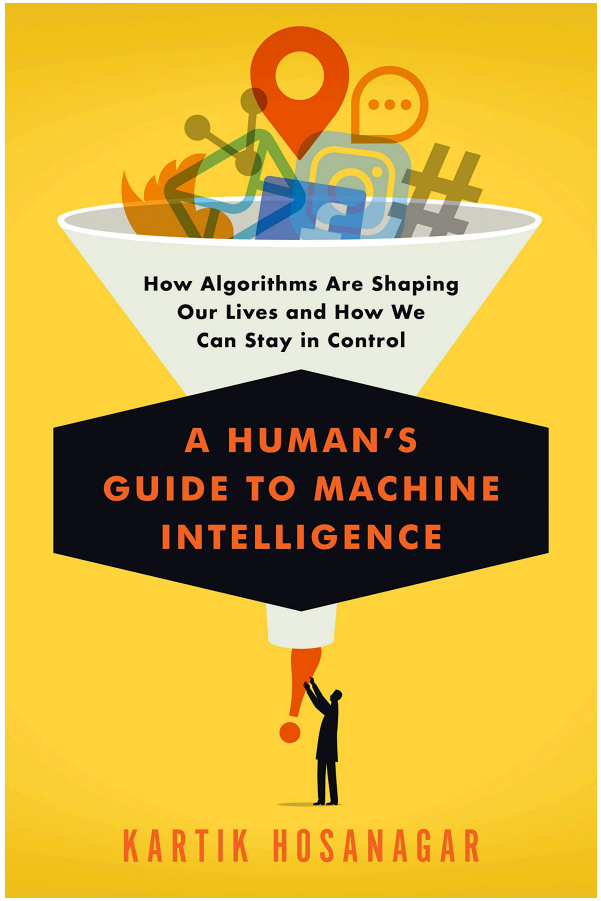
Announcements: Project

Quiz

Sources:

Much of the content for these slides has been taken from the book: “A Human’s Guide to Machine Intelligence” by Kartik Hosanagar

Additional sources are cited at the bottom of individual slides. Image citations can be found in the notes section of individual slides.




Wharton
University of Pennsylvania