Introduction to CMU first self driving car

Group 13

What are self driving cars ?

> A car, that can drive itself

> No need of human input

> To be more specific “a vehicle that uses a combination of sensors, cameras, radar and artificial intelligence (AI) to travel between destinations without a human operator. To qualify as fully autonomous, a vehicle must be able to navigate without human intervention to a predetermined destination over roads that have not been adapted for its use.”

How ?

> Same as us humans

> Not hard to teach it how to drive, accelerator = forward break = stop. The challenge it to drive good (aka, same as humans)

> Before we teach a machine how to drive, we first must teach it how to see. How to hear and if necessary how to think or feel ?

Q) See ? How can it see ?

Q) Hear ? How can it hear ? why should it ?

Q) Think ? Feel ? Are we still talking about a car ?

The Why ?

> The obvious answer

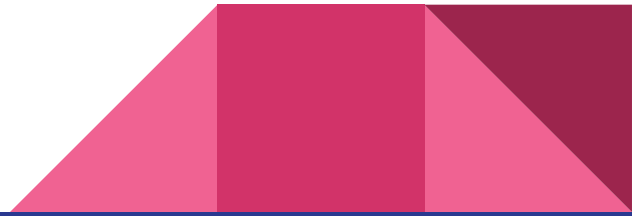
> Safety

> Greater personal independence

> Saving money

> Reduce congestion

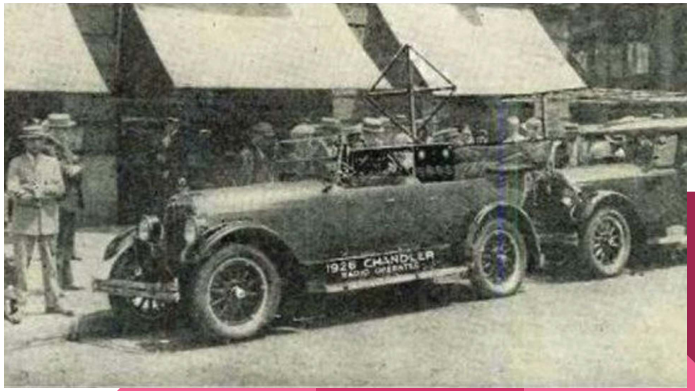
> Environmental gain



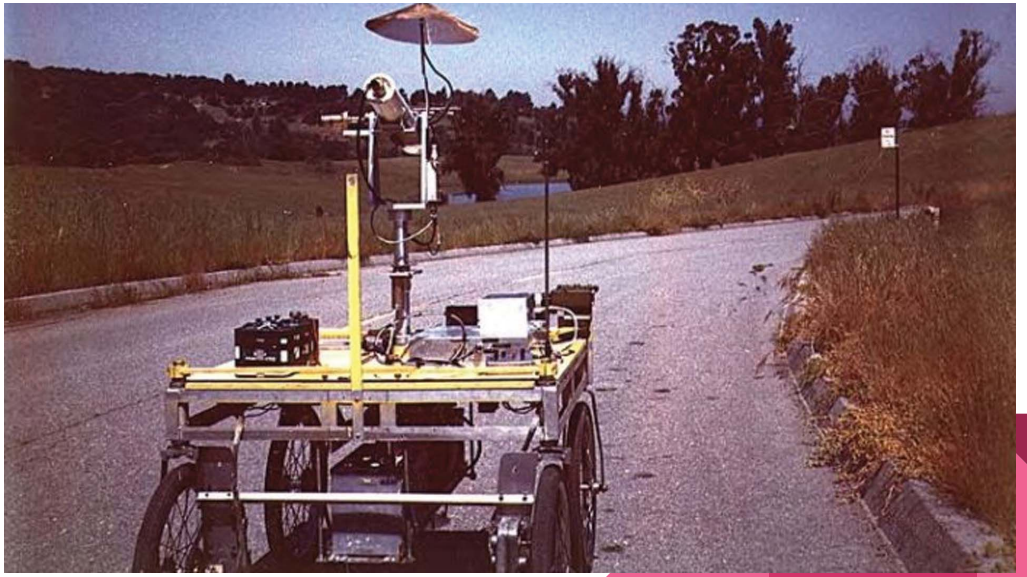
1977

Quick history lesson

> 1925 : Inventor Francis Houdina demonstrated a radio-controlled car through the streets of Manhattan without anyone at the steering wheel. The radio was able to start its engine, shift gears, and sound its horn. This car offered a glimpse into the future of autonomy but was quickly shut down when the operator lost control twice during the ride and crashed into another vehicle



> 1961 : Researchers began contemplating how to land vehicles on the moon. As a result, James Adams created the Stanford Cart, fitted with cameras and programmed to autonomously detect and follow a line on the ground. This was the first use of cameras in autonomous vehicles.



> 1977 : The Japanese improved on this idea with a camera system that relied data to a computer to process images of the road. This led to the testing of the world’s first self-driving passenger vehicle which could reach speeds up to 20 miles per hour.

> 1995 : Carnegie Mellon researchers took their self-driving car, called NavLab 5, to the road, traveling 2,797 miles from Pittsburgh to San Diego. They controlled the speed and braking, but the car was otherwise autonomous.

Cognitive Computing in autonomous vehicles

Why Cognitive model?

- Cognitive Computing system imitate the human brain by using data-mining and pattern recognition algorithms, which facilitate problem solving without human assistance.
- Systems are trained on large datasets to develop deeper understanding and reasoning of unstructured data to derive useful insights and respond more naturally as human would.

Cognitive Computing in autonomous vehicles

- Humans can observe objects, gauge characteristics, actions and relative positioning the surrounding environment, which enables **logical decision making**.
- Most State-of-the-art algorithms in machines detect only high-level information of objects such as **positions and types.**
- Cognitive analysis can help enhance the navigational accuracy of advanced driver assistance systems(ADAS).

Cognitive Computing in autonomous vehicles

Modeling Human Behavior:

- They must communicate with each other to share states and intentions.
  - **Example :** Caravanning, in which vehicles follow each other at impossibly close distances and at high speeds.
- It seemed natural to train a cognitive computing system that can estimate and quantify risk of errors based on the current states.

Cognitive Computing in autonomous vehicles

- IBM has been inventing, patenting and innovating new technologies for automotive industry for decades.
- OLLI, First self driving minibus to integrate the power of IBM cognitive computing platform Watson.
- Cognitive computing technologies could enable automakers to provide consumers with a new sense of confidence.
- Cognitive computing models can help human drivers and autonomous vehicles better share the road.

Cognitive Computing in autonomous vehicles

OLLI - Self driving minibus

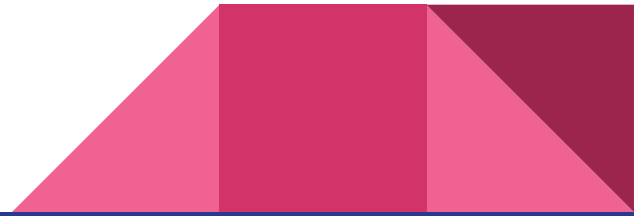
Cognitive Computing in autonomous vehicles

The National Highway Traffic Safety Administration(NHTSA) has proposed a system to classify vehicles with respect to autonomous capabilities, Ranging from

Level 0 - Driver is always in control.

To

Level 4 - Driver is not expected to control the vehicle at any time.



Opportunities

Safety

- “Traffic crashes remain the primary reason for death of Americans between 15 and 27 years of age.” (Eno, 2013).
- There are 5.5 million automobile accidents, 2.22 million fatal or injurious, per year in the United States in 2013, 93% of which are attributed to be caused by a human factor associated with alcohol, speeding, and distraction.
- The adoption of autonomous vehicles has the ability to greatly reduce or almost completely eliminate the number of crashes.

Mobility

- Many people do not drive because they are disabled, too young or too old. Making it very difficult for them to drive on their own.
- Autonomous vehicles will greatly enhance further mobility for these populations, which may in turn increase the well-being of these populations

Opportunities

Improved Road Efficiency

- Congestion and traffic operations can be reduced using autonomous vehicle through the use of sensors that can sense traffic flows by monitoring vehicle braking and acceleration through V2V monitoring. V2I monitoring can also be used to improve flow and safety in intersections and high-problem areas

Machines don’t get tired

- An important advantage of self-driving cars is that unlike humans, machines do not get tired

Robots are able to constantly focus

- We as humans get distracted by all kinds of things of our daily life. We may even look at our phones while driving from time. All those distractions increase the likelihood of serious accidents.

Disadvantages

Orientation (knowledge of position relative to surroundings)

- Multiple factors contribute to the orientation challenges faced by autonomous vehicles.
- The primary cause of this problem are the dynamic situations on the roads, such as road diversions, construction sites, and missing road signs and markings.

Liability

- When the driver is eliminated from the equation, the liability in case of an accident will fall on the car manufacturer and the suppliers of AV system hardware and software.
- Therefore, it is imperative that laws are revised, considering the presence of autonomous vehicles on public roads

Disadvantages

Security & Privacy

- A major concern in the debate surrounding AVs is the potential risk of a malicious attacker taking control of the car while in operation and provoking intentional accidents
- The same types of attacks that are possible in any connected device are generally possible in connected vehicles once access is gained.

Financial challenges

- High cost related to development and adoption of autonomous vehicles is a challenge.
- The technology and components, such as sensors and communication devices used in vehicles with higher levels of automation could result in these features being available in only premium tier production vehicles, raising questions about affordability for end-consumers

Challenges

- Building a safe system:
  - Track movement and speed of other vehicles to maintain same pace
  - In US, 1 death for 1 Million hour of human driving
- Data Availability:
  - Small amount of labelled data available for training
    - Hence use simulated data for training and fine tune with real-world data
  - Unlabelled data can be generated easily by mounting a lidar on the car and drive
  - Lidar is device used to detect the objects and surroundings as cloud of 3D points
- Build not just safe vehicle but also practical self-driving cars
  - Just having perfect Computer Vision doesn't help without programming the vehicle for all types of scenarios

Challenges

Consider an example:

- Self-driving vehicle moving at 70 kmph and detected a pedestrian who is away by 1.3 seconds if the same speed is maintained
- To stop the vehicle it needs to be decelerated by more than 6.5m/s^2
- Due to some restrictions in programming that the car is not allowed to decelerate at that high rate, there are chances to met with an accident
- So programming for all types of scenarios is required for practical self-driving cars
- Cognitive approach can solve such problems by having non-deterministic solutions and can use the best solution

The more the data we have, the more is the model performance.

Challenges

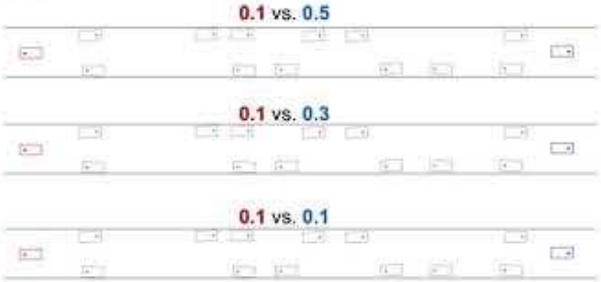
- Generally lidars are used for detecting the surroundings which are expensive and large in size
- Instead we can use radars for knowing about surroundings
- Lidars are poor in color contrast and not affordable
- Radars are affordable, small in size but have poor resolution and color contrast
- For color and contrast, we can use regular cameras and combine with radars
- For proximity, we can use ultrasonic sensors which is present in many recent cars
- Radars + Cameras + ultrasonic sensors is best combination to achieve all things by a self-driving at an affordable price

Challenges

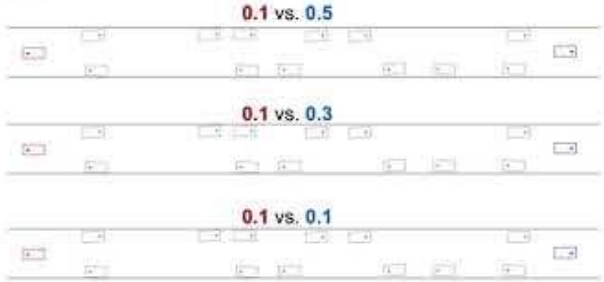
- Driving in narrow crowded streets, passing in less space and clearing traffic jams without human intervention is difficult for self driving cars
- Intent and degree of collaboration of other road users is unknown especially when both human driven and self driving vehicles are involved
- The environment is non-stationary since it is a multi-agent reinforcement learning
- Other agents also involved and changes the environment constantly
- Cooperativeness is a variable which needs to have optimal value for handling such type of scenarios
- Merging onto a highway, changing lanes or making a left/right turn against traffic at an intersection are some other challenges

Challenges

Interactions



Interactions



Future of Self-driving cars

- Some researches says that these vehicles come in high cost and requires more energy for long ranges
- Hence it reduce the usage of these autonomous vehicles drastically
- Suggested a need for gas-electric hybrid one but it was proven wrong by a paper published on June 2020, electric power can supply enough energy for an autonomous vehicle without a significant decrease in range
- Automation will likely reduce electric vehicle range by 5–10% for suburban driving and by 10–15% for city driving due to sensor drag and computing loads
- Self-driving cars may use more energy than people-driven cars to power sensors and computers
- On the other hand, they drive more smoothly than humans do, which would reduce energy use
- There is a decrease in driving range but not significant enough to eliminate the electric-powered self driving cars

Conclusion

We can conclude that the future of transportation is going to be changed by the autonomous vehicles with the improvements in technology. Researchers are trying to model all types of scenarios to reduce errors and make the autonomous vehicles available to everyone at affordable price. Computer Vision is highly being used and in a cognitive way for better understanding of scenarios and making the models. Autonomous vehicles is a trending research topic and need to be required for improving the transportation facilities.

References

- https://www.ibm.com/blogs/research/2017/03/cognitive-computing-autonomous-vehicles/
- https://www.tcs.com/blogs/cognitive-analytics-make-autonomous-cars-smart
- https://www.cmu.edu/news/stories/archives/2020/june/more-data-for-self-driving-cars.html
- https://www.cmu.edu/news/stories/archives/2021/july/new-algorithm-for-narrow-streets.html
- https://www.cmu.edu/news/stories/archives/2020/july/electric-autonomous-vehicles.html

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THANK YOU