Topic: Self-driving (autonomous) vehicles.
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Useful entities:

Sensors/Cameras

- The computer vision technology can gather large sets of data using cameras and sensors including location information, traffic conditions, road maintenance, and crowded areas and others. These detailed data can assist self-driving vehicles to use situational awareness and make vital decisions as soon as possible.
- The vehicle can use LiDar sensors and cameras, and the former can use pulsed laser beams to measure distance. The data obtained can be combined with 3D maps to spot objects like traffic lights, vehicles, and pedestrians.
- Computer vision detects low-light condition it can shift to low-light mode. Such data can be obtained using LiDar sensors, thermal cameras, and HDR sensors. These types of equipment can be used to create high-quality images and videos.

3D- Maps

- It will enable self-driving vehicles to capture visual data in real time. The cameras attached with such vehicles can record live footage and allow computer vision to create 3D maps. Using these maps, autonomous vehicles can understand their surroundings better while spotting obstacles in their path and opt for alternate routes with 3D maps.
- Self-driving vehicles can predict accidents using 3D maps and can instantly deploy airbags for the protection of the passengers. This solution makes self-driving cars more safe and reliable. Therefore, technology can help build safe autonomous vehicles to avoid accidents and protect passengers. Hence, computer vision can help in building self-driving vehicles that can avoid accidents and protect passengers in the event of a crash.

Object detection

- It is very important to identify any objects like Pedestrian, 3D-Objects, trees, etc. Some of the important tasks are like Image Classification, Object Detection, Scene Segmentation, and Driving Lane Detection.

Control: Processing data and Path Planning

- Once the Computer Vision system has processed the data from the sensors, the self-driving car now has all the information it needs to drive. The role of the **control** stage is to figure out how to best navigate the car based on the information extracted during the understanding stage.
- The goal of path planning is to use the information captured by the Computer Vision system to safely direct the car to its destination while avoiding obstacles and following the rules of the road.

Limitations

- Sensors/Cameras: Do we have high quality sensors and cameras to identify all the objects nearby the car? LiDar sensors today gives a better sense of the surroundings but it is very costly. On the other hand, company like Tesla don't want to use LiDar and instead using 8 cameras to solve the same problem.
- Gathering Data for Training Algorithms: The computer vision technology can gather large sets of data using cameras and sensors including location information, traffic conditions, road maintenance, and crowded areas and others. These detailed data can assist self-driving vehicles to use situational awareness and make vital decisions as soon as possible. These details can be further used in training deep learning models. It is not easy to get these sort of real data, like data with crowded areas, low visibility, muddy area, snowy area, raining environment, mixed of different scenarios, etc.
- Detecting Blind spot: We human do have blind spot while driving the car. Can we make self-driving car blind spot free? If we are making then at what cost. Is it going to get affordable too?

- Security and Adversarial attack: What if someone hack the system like manipulate the ML models that is responsible for making the key decisions like object detection and understanding the surroundings. White-box or black-box adversarial attack can be catastrophic.
- Real-time Compute**:** We need high speed CPUs/GPUs to process the data in real-time and take actions. Do we have such hardware today to solve all the scenarios that can arise in real-time?
- Understanding the environments: It is very hard to understand the dynamic environment. For eg, if the system sees a new data where number of people/objects seen in the environment is way much then it was trained on then the model might not work as expected because of randomness/noise in the data. Do we have any model to mitigate and understand these sorts of data?
- Machine error: How to handle in case of error. Machine error must be taken into consideration when examining the pros and cons of driverless cars. While most agree self-driving cars will likely prevent more accidents from happening, it does not completely eliminate the risk of accidents caused by machine error. Furthermore, if the software or any part of the vehicle fails, an autonomous vehicle could put the driver in more danger than if the driver was to personally take control of the vehicle.
- Moral Machine dilemma: Another one of the limitations to self-driving cars is their lack of ability to make judgments between multiple unfavorable outcomes. For example, what if a self-driving car had to face a situation with only two possible options:
  Veering to the left and striking a pedestrian, or
  Veering to the right and hitting a tree, potentially injuring passengers inside your vehicle

Since both options are undesirable, which option would the autonomous car choose? The Moral Machine, developed by a group at MIT, is seeking to address this issue by collecting data on real-life people's decisions. However, the data collected shows broad differences amongst different people groups, making it difficult to program any definitive answer for autonomous cars.

<u>Feasibility of meeting the needs and overcoming the technical obstacles</u>

- Compute: With the advent of fast-processing compute like faster GPUs, we do see there has been great advancement in object/image detection but for self-driving car which needs processing to be done in real-time, we do need a more powerful compute and these looks to be feasible in next 3-5 years.
- Sensors: LiDar sensor is good and solving some of the really difficult tasks in environment sensing but it is costly. Tesla solving with 8 cameras and using deep neural networks seems promising and I believe this can be done without LiDar sensor as well.
- Training: I do see an issue with training the models as we need a ton of data with different scenarios. Environment is dynamic in nature. Environment can have moving peoples, roads, lanes, different weather conditions (foggy, muddy, rainy), different objects types, etc. This is one of the obstacle which doesn't seems can be solved in 3-5 years.
- Computer Vision Models/Algorithms: Till date, we don't have models which solves the problems like object detection, image classification, scene segmentation, driving lane detection with very high accuracy. With the time, the results are going upward in terms of accuracy and it shows that self-driving car will make significant advancement in terms of computer vision tasks.

Refernces

[1] https://www.analyticsinsight.net/computer-vision-makes-autonomous-vehicles-intelligent-and-reliable/
[2] https://www.sciencedirect.com/science/article/pii/S2590005621000059
[3] https://towardsdatascience.com/your-guide-to-ai-for-self-driving-cars-in-2020-218289719619