# CS 4300 - Fall 2022 - Minh Nguyen
# Environment Abstraction and Simplification

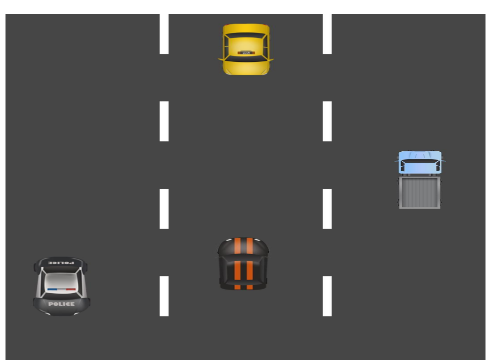
## I. Self-driving and parking vehicles:

### 1. Description:

Self-driving and parking vehicles are created to solve our modern world's driving problems. The application of AI in automated vehicles allows them to map out the surrounding area, recognize the space around the vehicle, and make decisions accordingly. The purpose of self-driving cars is, first of all, to reduce crashes and save lives. Unlike humans, computers or programs do not have attention issues while driving, and self-driving cars can avoid accidents by detecting and reacting to hazardous situations on the road ahead of time. Second, self-driving cars help decrease traffic congestion since they can be programmed to travel at constant speeds, which would avoid the slowdowns caused when one driver goes too slowly. Third, they improve safety and make transportation more accessible for people who cannot drive. Many people cannot drive for various reasons, including lack of experience, disability, or age. Automated vehicles can be a much safer mode of transportation for these people, allowing them greater independence. Additionally, a fully automated vehicle makes driving more convenient. People who cannot drive for physical or mental reasons will have more travel options with an autonomous vehicle.

### 2. Abstractions and Simplification:

- Assume that the car drives in the best weather conditions.
- The car does not need to find a path to any destination or have different modes.
- The environment can be something like a 2D driving game with 3 lanes, and the car only goes forward.



3. **The Percepts (Sensors):**
   a. Lidar (light detection and ranging):
      i. Front and back - this is an integer in the range [0, 3*car size] for how close or far an object is in front of the car or behind it.
      ii. Left and right - this is an integer in the range [0, 3*car size] for how close or far an object is to the 2 sides of the car.

   b. Radar (radio detection and ranging):
      i. Object's velocity - an integer in the range [0, 200] for how fast or slow an object is moving.

   c. Sonar (sound navigation and ranging):
      i. This is an integer in the range [0, 1] for how light or dense an object is.
      ii. For this environment, 0 will be the density of a pedestrian and 1 will be the density of another car.

   d. Image sensor:
      i. An input image is broken down into pixels as a 2D array where each pixel is an integer in the range [0, 255] from completely black to completely white.
      ii. Only need to recognize: other cars, pedestrians, and traffic lights, speed limit signs.

   e. The vehicle itself:
      i. Velocity - an integer in the range [0, 200] for how fast or slow the car is moving.
      ii. Gas level - a float in the range [0, 1] from empty (complete stop) to full (max speed).

4. **The Actions (Actuators):**
   a. Accelerate:
      i. Increase the speed of the car (increase the gas level)
      ii. The speed must be in the range [speed limit - 5, speed limit + 5]

   b. Decelerate:
      i. Decrease the speed of the car (eventually to a full stop)
      ii. The decrease of the speed depends on how fast the car is, how far or close an object is from the car, whether the car is turning, and whether there is a traffic sign/signal the car needs to follow.

c. Turn left and right:
   i. Change the direction of the car.
   ii. The car will still move forward while changing the lane.

5. **The Environment:**
   a. Observability:
      i. Partially observable
      ii. All objects, such as other vehicles, pedestrians, or speed limit signs, are not showing up all at once, so the car can only see the things when it is at a certain location on the road. But within that limit, all of the information is available.

   b. Uncertainty:
      i. Deterministic
      ii. The behavior of other objects is expected. For example, no other car will suddenly change lanes, or no pedestrian will randomly show up in the middle of the road in front of the car.

   c. Duration:
      i. Sequential.
      ii. Since new objects will come up as the car moves to a next location on the road. It needs to take in the percepts, make decisions accordingly, and repeat the process.

   d. Stability:
      i. Dynamic.
      ii. As mentioned above, different objects with different impacts to the traffic will show up as the car moves forward. However, the behavior of those objects is static.

   e. Granularity:
      i. Continuous.
      ii. The car is moving continuously, when it sees traffic signs, a pedestrian crossing the road, or when it gets too close to the car in front of it.

   f. Participants:
      i. Multi-agent - there are different objects on the road.
      ii. Single-agent - only the self-driving car’s decision will affect the traffic flow.

g. Knowledge:
    i. Known - The laws, the road, the physics of driving a car, as well as every action's outcome are known.

6. **The Performance Measure:**
    a. Recognize speed limit sign:
        i. +5 points if follow
        ii. -50 points otherwise

    b. The car's speed must be in the range [speed limit - 5, speed limit + 5]
        i. Reward: 1 point per mile
        ii. Penalty: -10 points per second

    c. Recognize traffic lights:
        i. +5 points if follow
        ii. -50 points otherwise

    d. Red traffic light:
        i. +5 points if slow down to a full stop
        ii. -50 points otherwise

    e. Green traffic light:
        i. +0 points if it is green by the time the car reach it and keeps going
        ii. +5 points if the car accelerates when the light changes from red to green.
        iii. -50 points if the car does not move

    f. Recognize pedestrians crossing the road:
        i. +5 points if follow
        ii. -50 points otherwise

    g. Yield for pedestrians:
        i. +5 points if follow
        ii. -50 points otherwise

    h. Collision:
        i. -200 points if collide with another vehicle
        ii. -500 points if collide with a pedestrian