

# Motion Prediction

Course 4, Module 4, Lesson 1



UNIVERSITY OF TORONTO  
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# Learning Objectives

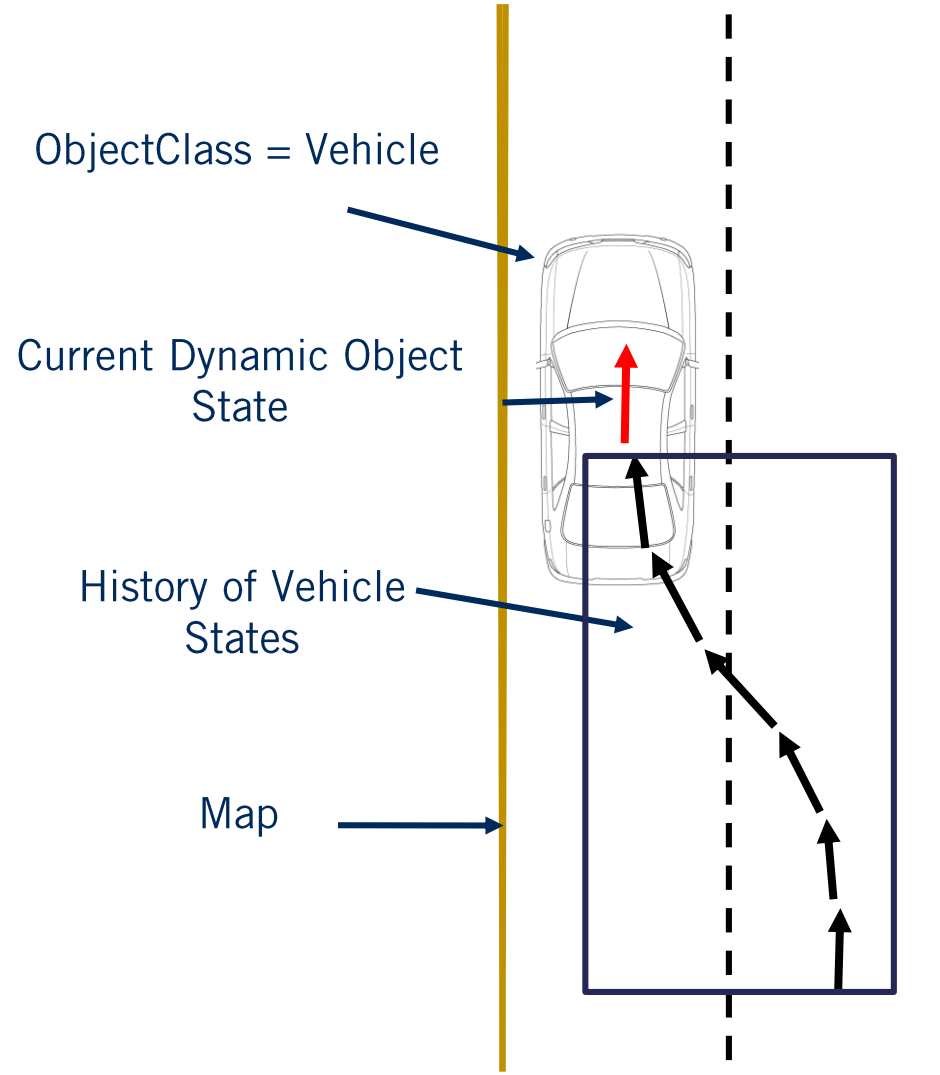
- Define the motion prediction problem for dynamic objects and its importance to planning
- Identify the requirements for accurate motion prediction
- Perform predictions with the Constant Velocity Prediction Model

# Motion Prediction - Definition

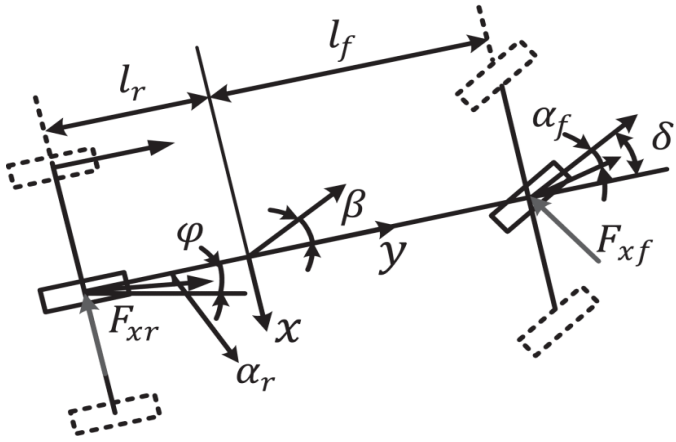
- Motion prediction of the dynamic object's attempts to estimate the future position, heading and velocity
- Important as it allows:
  - Planning a set of maneuvers to correctly interact with dynamic objects
  - Avoid collisions on a planned trajectory

# Requirements for Motion Prediction Models

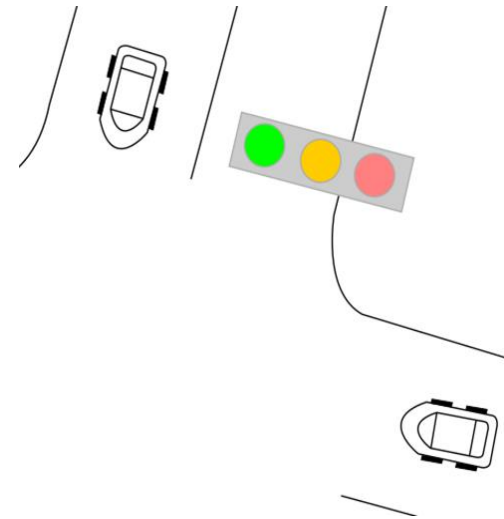
- **Mandatory Requirements:**
  - Class of Dynamic Object
  - Current position, heading and velocity
- **Optional Requirements:**
  - History of the position, heading and velocity
    - Requires object tracking between identifications over a set amount of time
  - Current high definition roadmap
  - Image of the current dynamic object



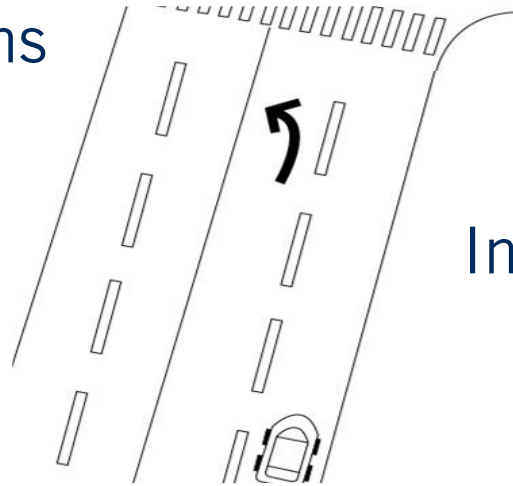
# Simplification of Motion Prediction - Cars



Physics-based Assumptions



Interactions-aware Assumptions



Maneuver-based Assumptions

# Complexities of Motion Prediction - Pedestrians

Pedestrians are unpredictable!



Can rapidly change speed and heading



Pedestrians use crossings  
Pedestrians use sidewalks



Pedestrians have right of way, but will stop if threatened

# Constant Velocity Prediction Model

- Simple
- Computationally efficient
- Assumption is that the dynamic object will maintain its velocity
  - Magnitude
  - Heading

# Constant Velocity Prediction Model - Algorithm

- Input:
  - $T$  – time horizon to predict over
  - $dt$  – time between predictions
  - $x_{obj}$  – current dynamic object state
    - Position:  $x_{obj}.pos$
    - Velocity :  $x_{obj}.vel$
- Output:
  - $x_{1:T}$  – list of future vehicle states

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## Algorithm Constant Velocity Prediction( $x_{obj}$ )

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```
1.   $t \leftarrow 0$ 
2.   $x_0 = x_{obj}$ 
3.  while  $t * dt < T$  do
4.       $t = t + 1$ 
5.       $x_t.pos \leftarrow x_{t-1}.pos + dt * x_{t-1}.vel$ 
6.       $x_t.vel \leftarrow x_{t-1}.vel$ 
7.  end while
8.  return  $x_{1:T}$ 
```

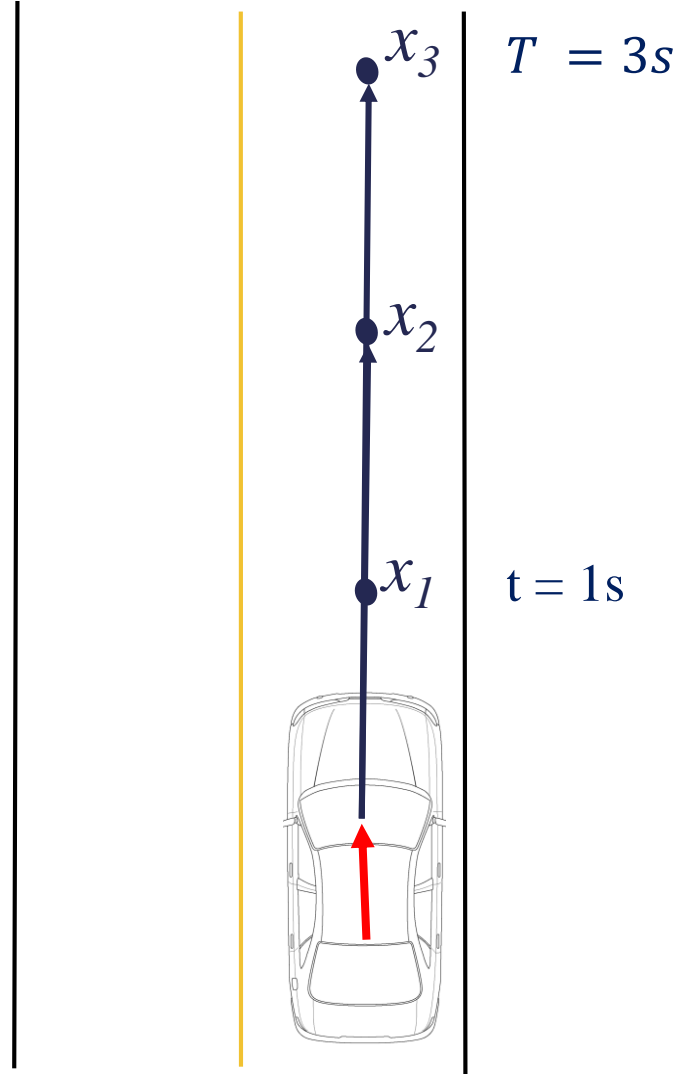
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# Constant Velocity Prediction Model - Example

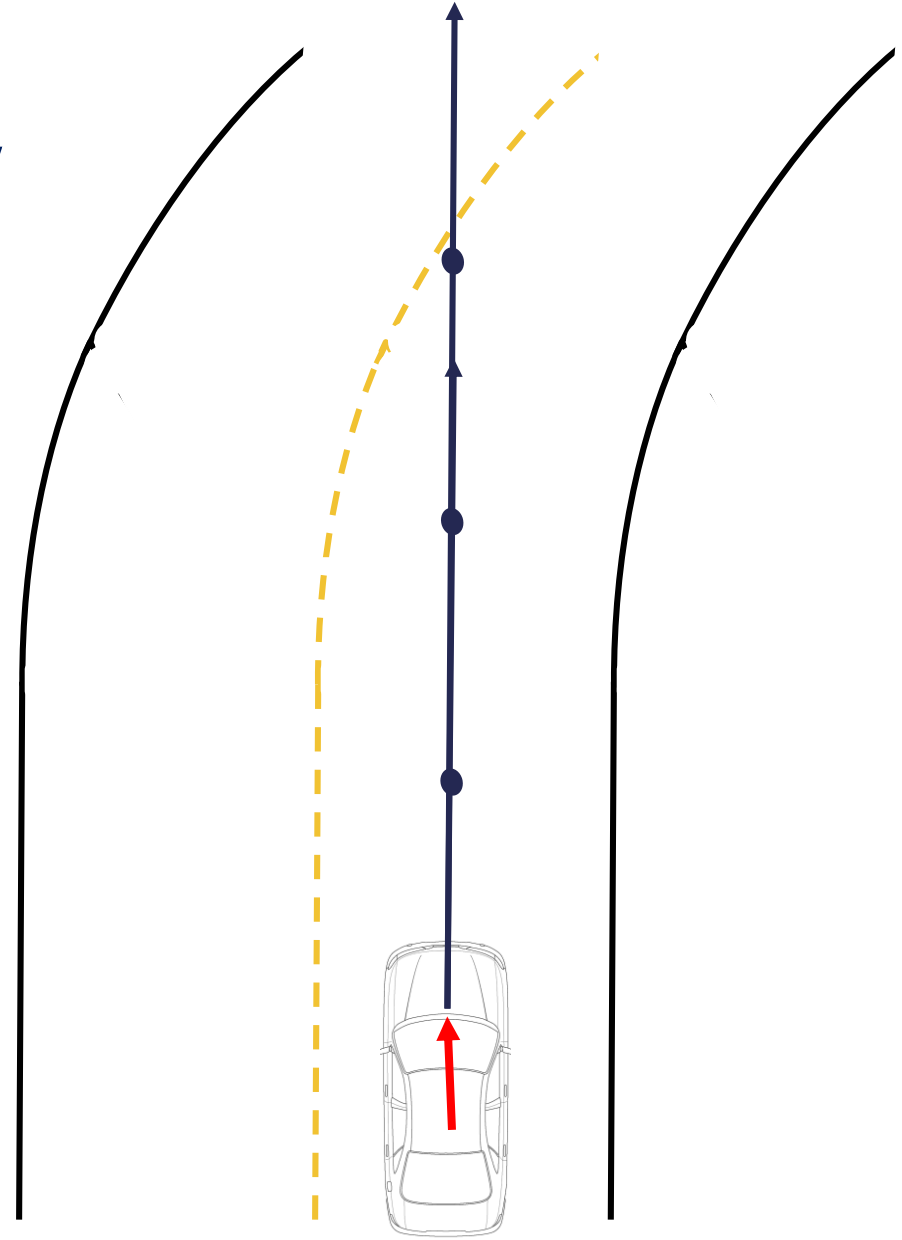
- Input:
  - $T = 3$  seconds
  - $dt = 1$  second
  - $x_{obj}$
- Output:
  - *Predictions*

$x_1$        $x_2$        $x_3$



# Constant Velocity Prediction Model - Issues

- Don't account for Vehicle Dynamics fully
- Don't account for the Road (Position adjustment)
- Don't account for Road Signs (Velocity adjustment)
- Assumptions are too Strong and Incorrect for most Dynamic Object Motion



# Summary

- Identified motion prediction and its Importance
- Requirements for motion prediction
- Assumption for Simplifying the problem in the case of
  - Vehicles
  - Pedestrians
- Simple Constant Velocity Prediction Model
- Issues with Simple Constant Velocity Prediction Model
- **Next:** Map-aware Motion Prediction Model