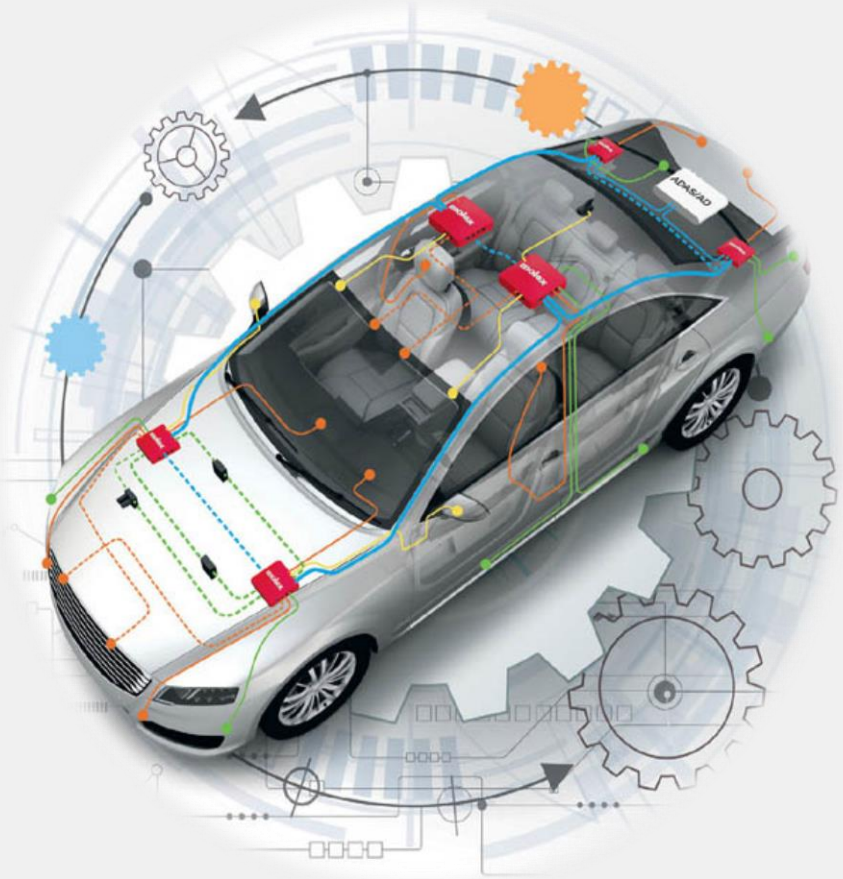
Control System of Self Driving Cars

Modelling Motion with MAP (Motion Aware Prediction)

Learning Objectives

AUGMENTED STARTUPS
Computer Vision | AI | Robotics

- **Motion Prediction with Dynamic Objects**
  - Definition
  - Importance
  - Requirements
  - Complexities & Solution
    - Cars
    - Pedestrians
- **Constant Velocity Prediction Model**
  - General Concepts
  - Algorithm
  - Example
- **Issues with Constant Velocity Prediction Model**
- **Summary**



Motion Prediction – Definition

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- **Motion prediction of the dynamic object's attempt to estimate the future position, heading, and velocity.**

Motion Prediction – Importance

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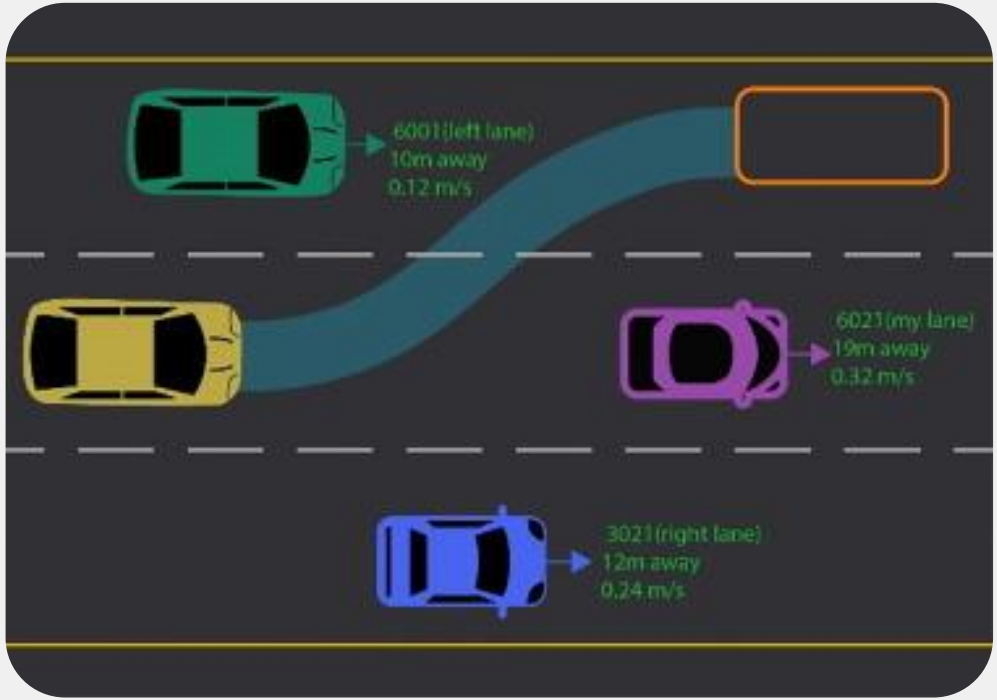
- **Creating/Planning a set of motion skills to correctly interact with dynamic objects.**

- **Collision avoidance on the planned trajectory.**



Motion Prediction – Requirement

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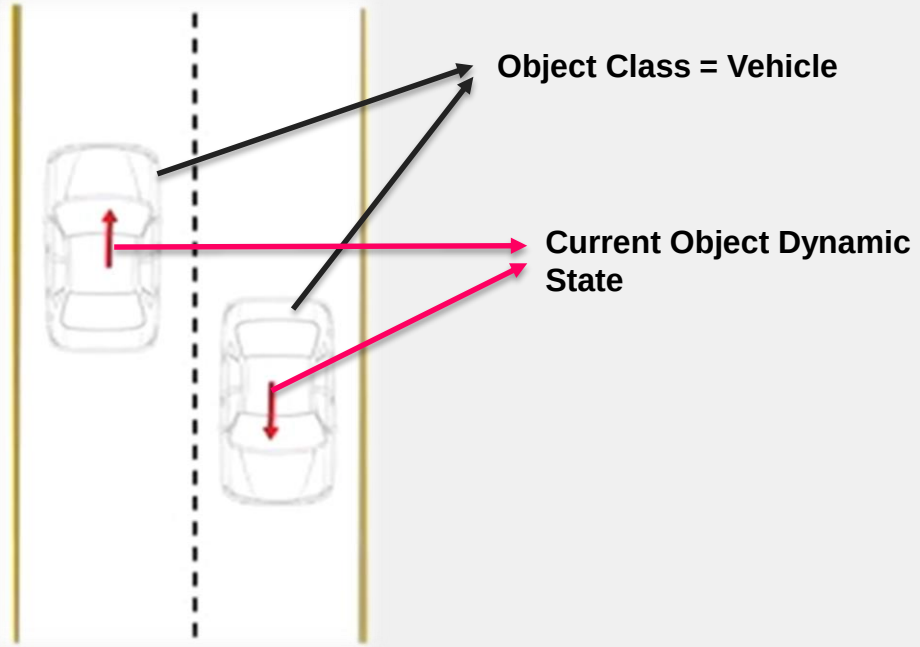
- **Mandatory requirements:**
  - **Class of Dynamic Objects**
  - **Current Position, Heading, & Velocity**



Motion Prediction – Requirement

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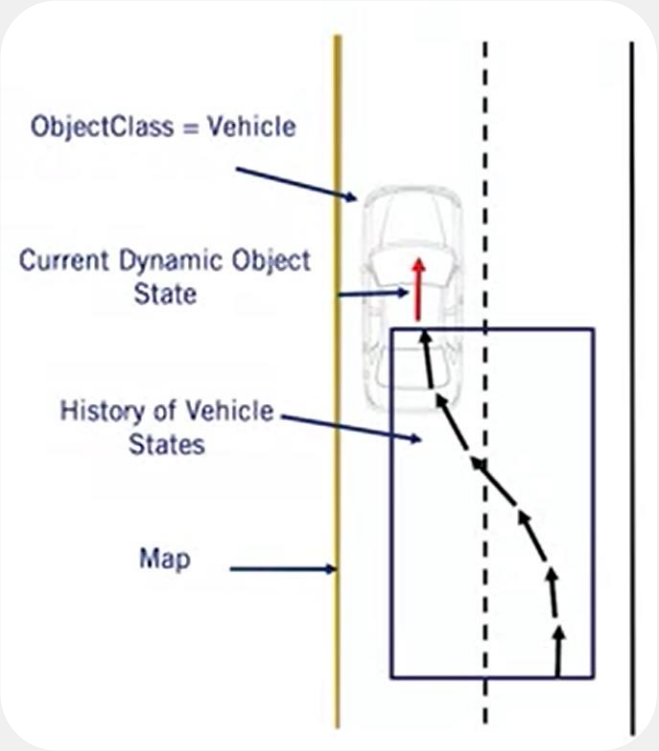
- **Optional requirements:**
  - **History of Position, Heading, & Velocity**
  - **Current High Definition Road Map**
  - **Image of Current Dynamic Object**



Motion Prediction – Complexities & Solution | Cars

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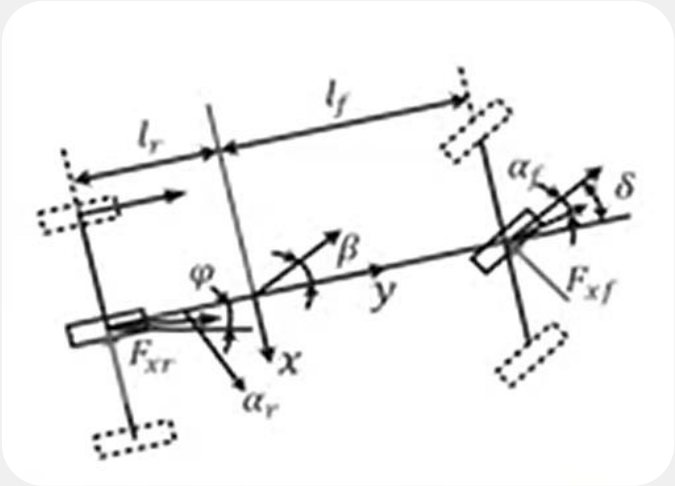
- **Physics Based Prediction**
  - **Vehicle must follow a set of physical constraints governing their movement.**
  - **These vehicle dynamics can be applied to predict their motion.**



Motion Prediction – Complexities & Solution | Cars

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- **Maneuver Based Prediction**
  - **All motions by vehicle on the road, are made up of a finite set of maneuvers in a restricted domain.**
  - **Must stay on the road.**
  - **Must follow the driving rules.**

Motion Prediction – Complexities & Solution | Cars

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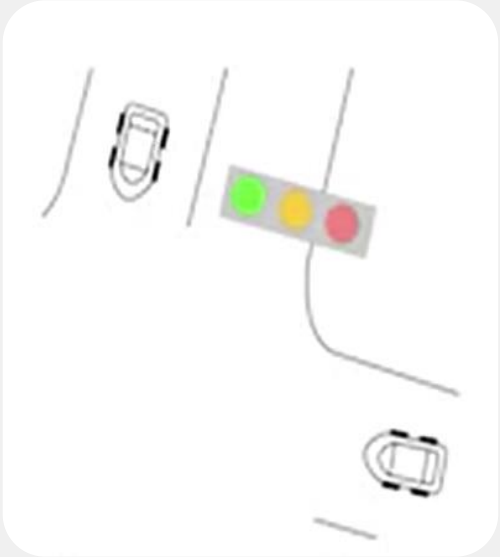
- **Interactions Aware Assumptions**
  - **Same assumptions as maneuver based.**
  - **Not only evaluate each vehicle independently.**
  - **Can also incorporate the assumptions that dynamic objects will react & interact with each other.**



Motion Prediction – Complexities & Solution | Cars

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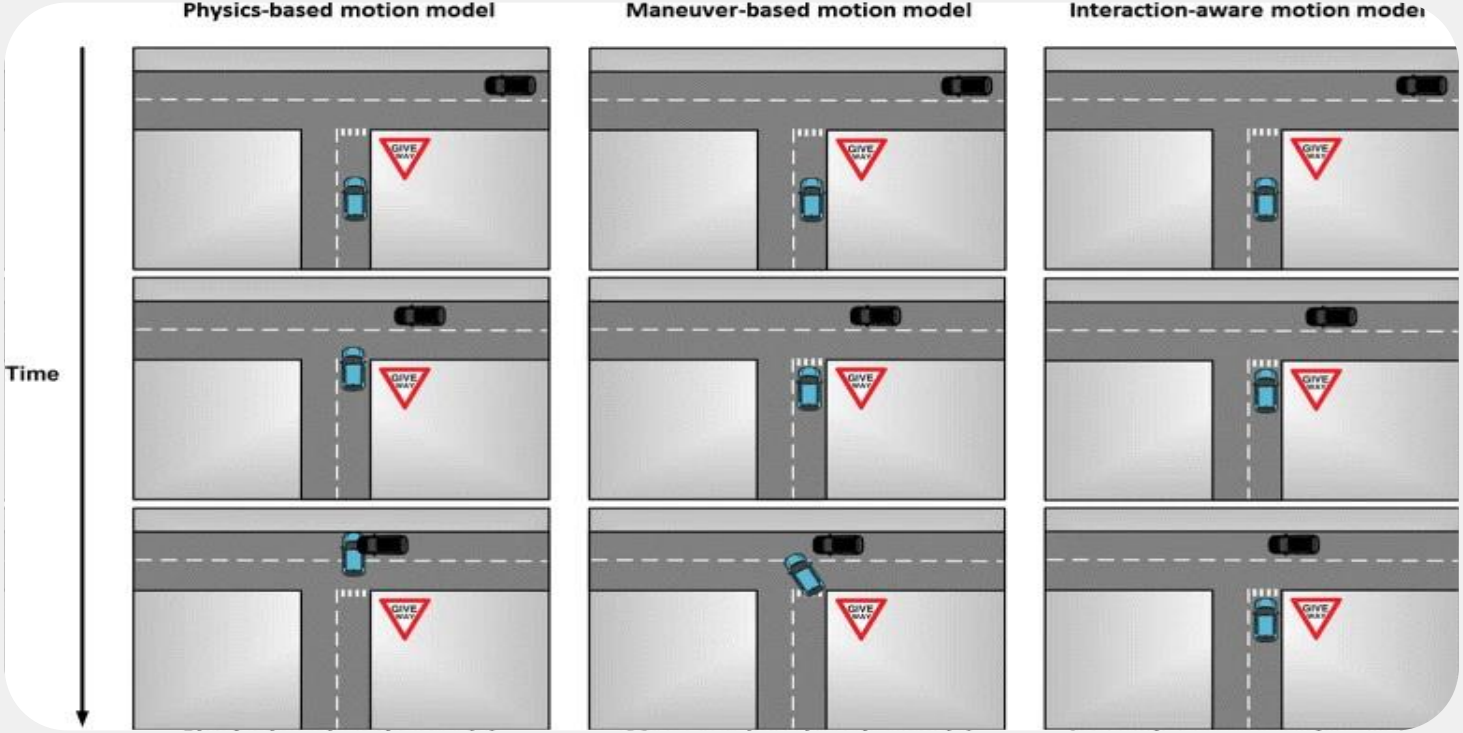

Examples of Motion Prediction with Different Models

Motion Prediction – Complexities & Solution | Cars

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Target	Variables	Challenges	Tools
Interaction Aware Models	• Social Conventions • Joint Activities • Communications	• Detecting Interactions • Identifying Interactions • Combinatorial Explosion	• Coupled HMMs • Dynamically Linked HMMs • Rule Based Systems
Maneuver Based Models	• Intentions • Perceptions • Surrounding objects & Places	• Un-observability • Complexity of Intentional Behavior	• Clustering • Planning as Prediction • Hidden Markov Models • Goal Oriented Models • Reinforcement Learning
Physical Based Models	• Kinematics • Dynamic Properties	• State Estimation from Noisy Sensors • Sensitivity of Initial Conditions	• Kalman Filters • Monte Cario Sampling

Differences of Motion Prediction Models with Key Points

Motion Prediction – Complexities & Solution | Pedestrians

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- Pedestrians are unpredictable.
- Can rapidly change speed & heading.
- Have right of way but will stop if threatened.
- Use crossings & side walks.

Constant Velocity Prediction Model

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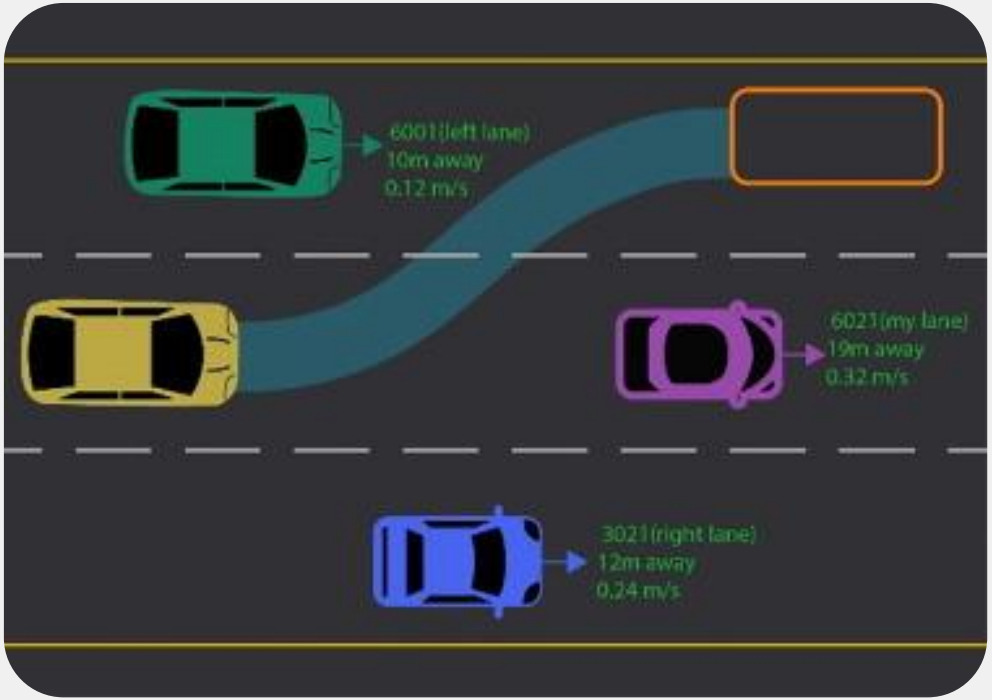
- **Simple**
- **Computationally Efficient**
- **Dynamic Object will Maintain:**
  - **Magnitude**
  - **Heading**



Constant Velocity Prediction Model – Algorithm

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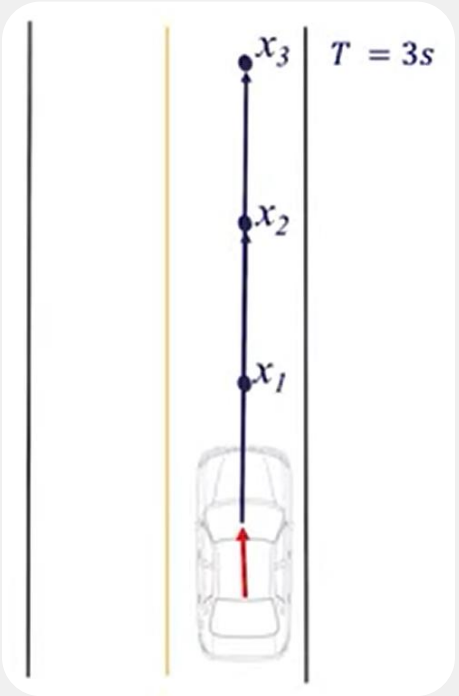
- **Input**
  - $T \rightarrow Time\ for\ prediction$
  - $dt \rightarrow Time\ change\ between\ predictions$
  - $x_{obj} \rightarrow Current\ dynamic\ object\ state$
    - $x_{obj-pos} \rightarrow for\ position$
    - $x_{obj-vel} \rightarrow for\ velocity$
- **Output**
  - $x_{1:T} \rightarrow List\ of\ future\ vehicle\ states$

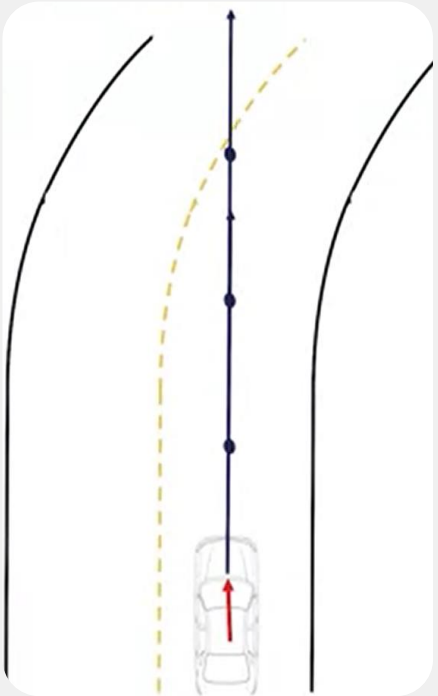
1. $x_{obj} \rightarrow 0$
2. $x_o = x_{obj}$
3. $while\ t * dt < T\ do$
   - $t = t + 1$
   - $x_t.pos \rightarrow x_{t-1}.pos + dt * x_{t-1}.vel$
   - $x_t.vel \rightarrow x_{t-1}.vel$
4. $end\ while$
5. $return\ x_{1:T}$

Constant Velocity Prediction Model - Example

- **Input**
  - $T = 3\ seconds$
  - $dt = 1\ seconds$
  - x_{obj}

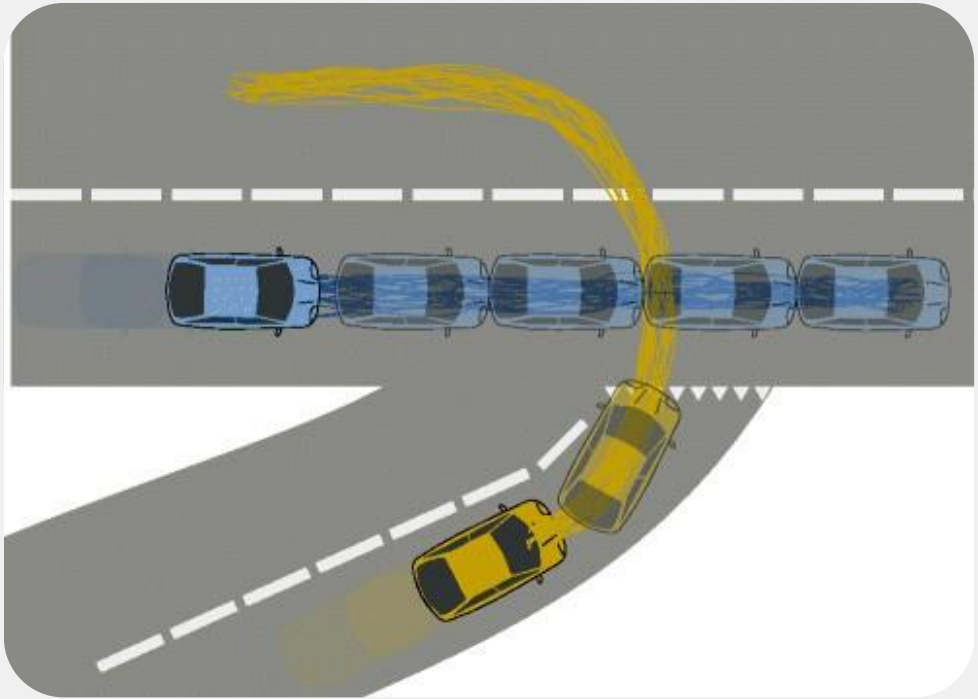
- **Output**
  - $Predictions$
    - x_1
    - x_2
    - x_3





Constant Velocity Prediction Model – Issues

- **Don’t account for:**
  - **Vehicle Dynamics Fully**
  - **Road (Position Adjustment)**
  - **Road Signs (Velocity Adjustments)**
- **Assumptions are too Strong & Incorrect.**



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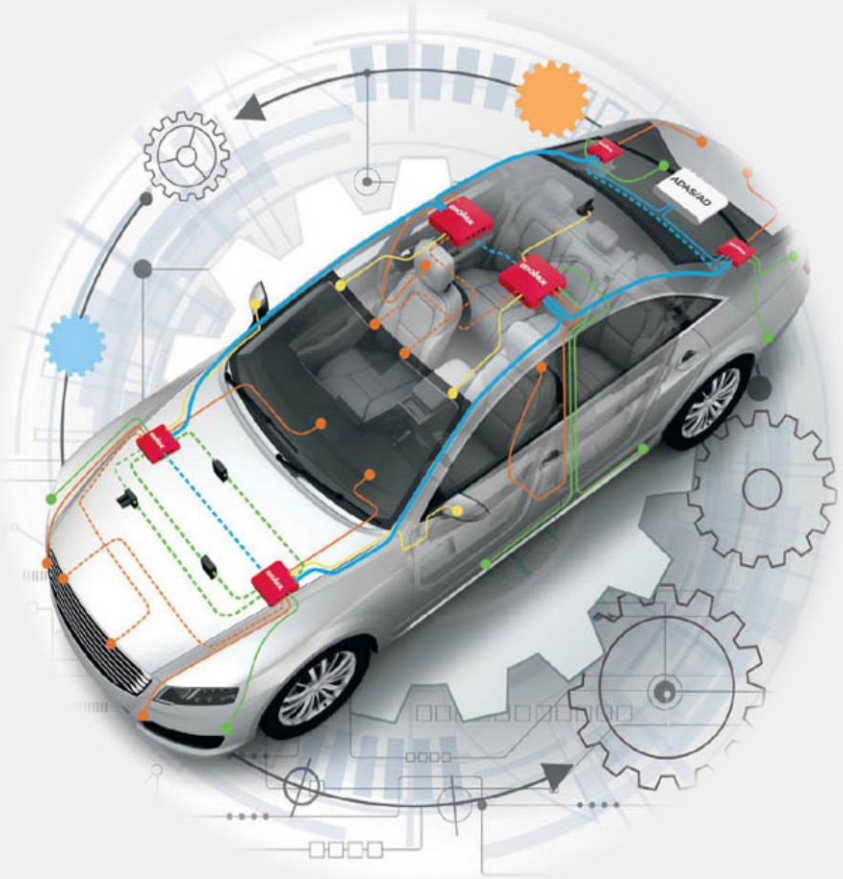

Reference

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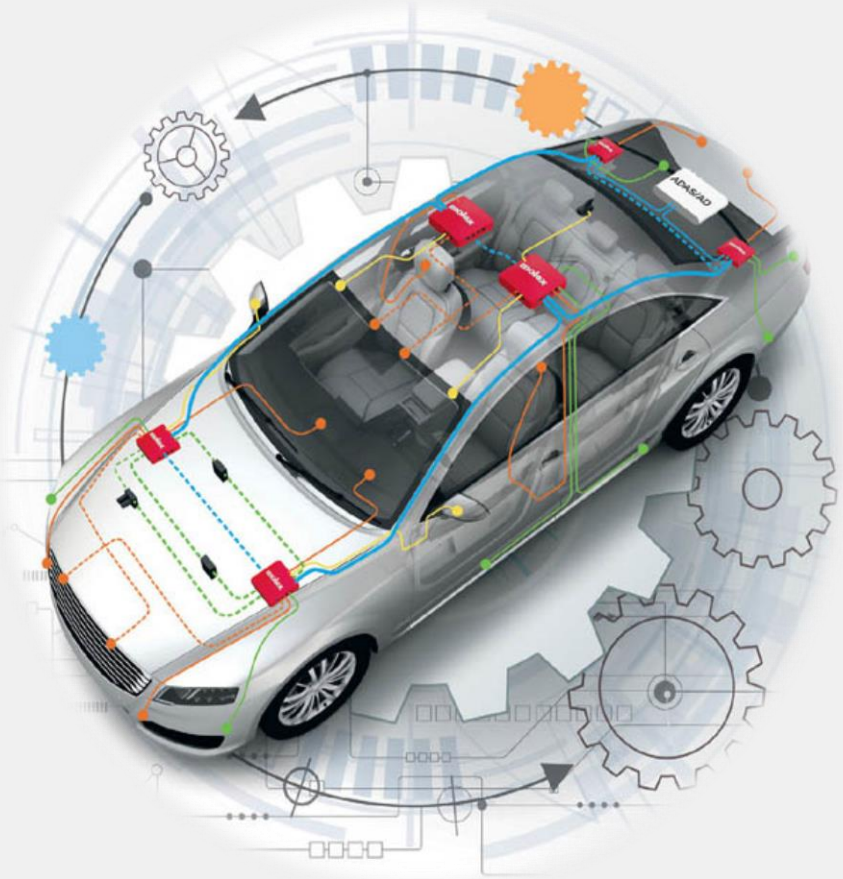

Thanks