# Advanced Methods for Behavior Planning

C4M5L5 by Marko Illievski

UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE & ENGINEERING

# Learning Objectives

- Identify issues with the state machine based behaviour planner
- Identify the open areas of research in behaviour planning

# State Machine Behaviour Planning Issues

- Rule-explosion when Dealing with Complex Scenarios
- Dealing with a Noisy Environment
- Hyperparameter Tuning
- Incapable of Dealing with Unencountered Scenarios

# Rule-Based Behaviour Planner

- Hierarchy of rules
  - Safety critical
  - Defensive driving
  - Ride comfort
  - Nominal behaviours
- Reduced need for duplication
  - Rules can apply throughout ODD

Operational design domain

- Suffer from same challenges as finite state machines
  - Common to all expert system designs

relies on expert users to design for all possible scenarios.

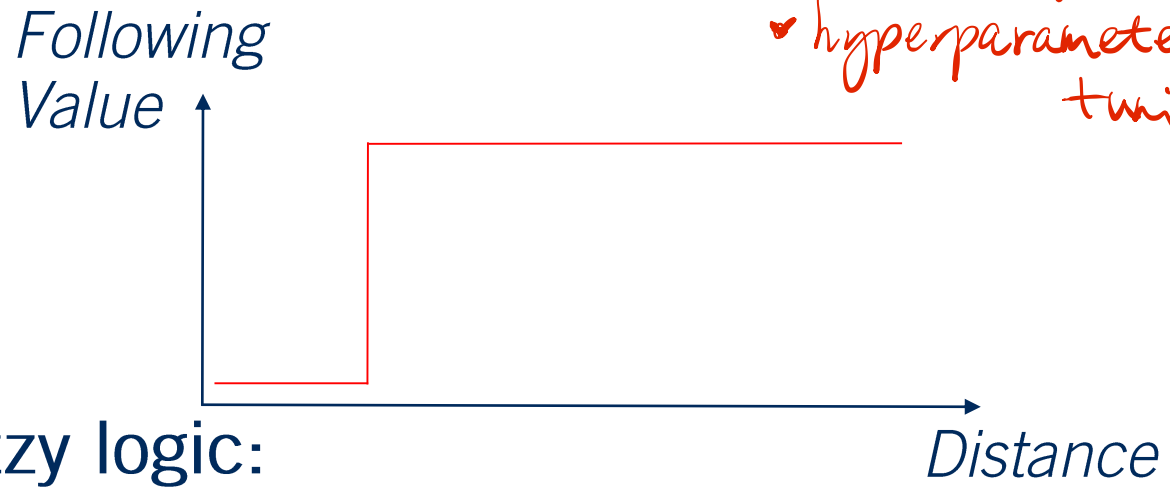
# Fuzzy Logic

Human expert

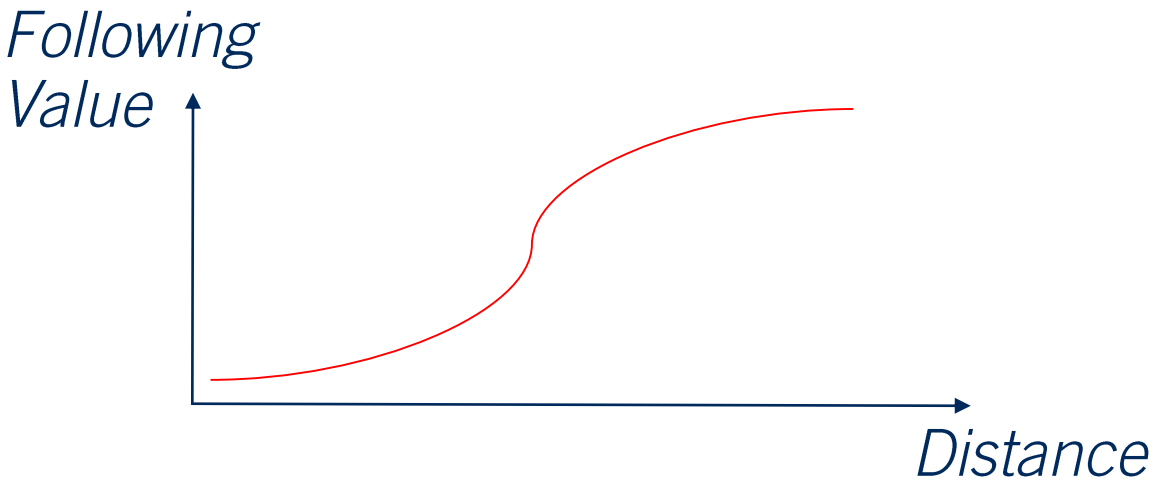
Pros: can deal with environmental noise somewhat

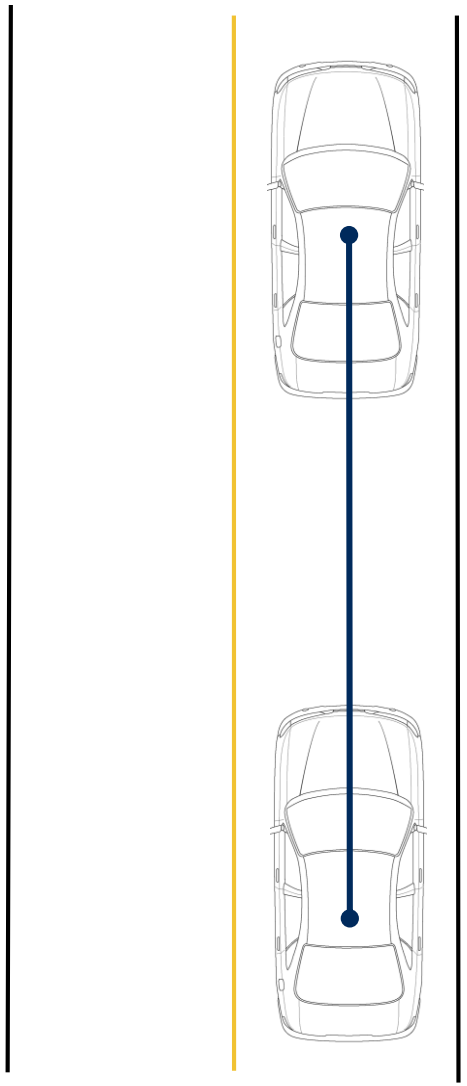
Cons: • rule explosion
• hyperparameter tuning.

Non Fuzzy logic:



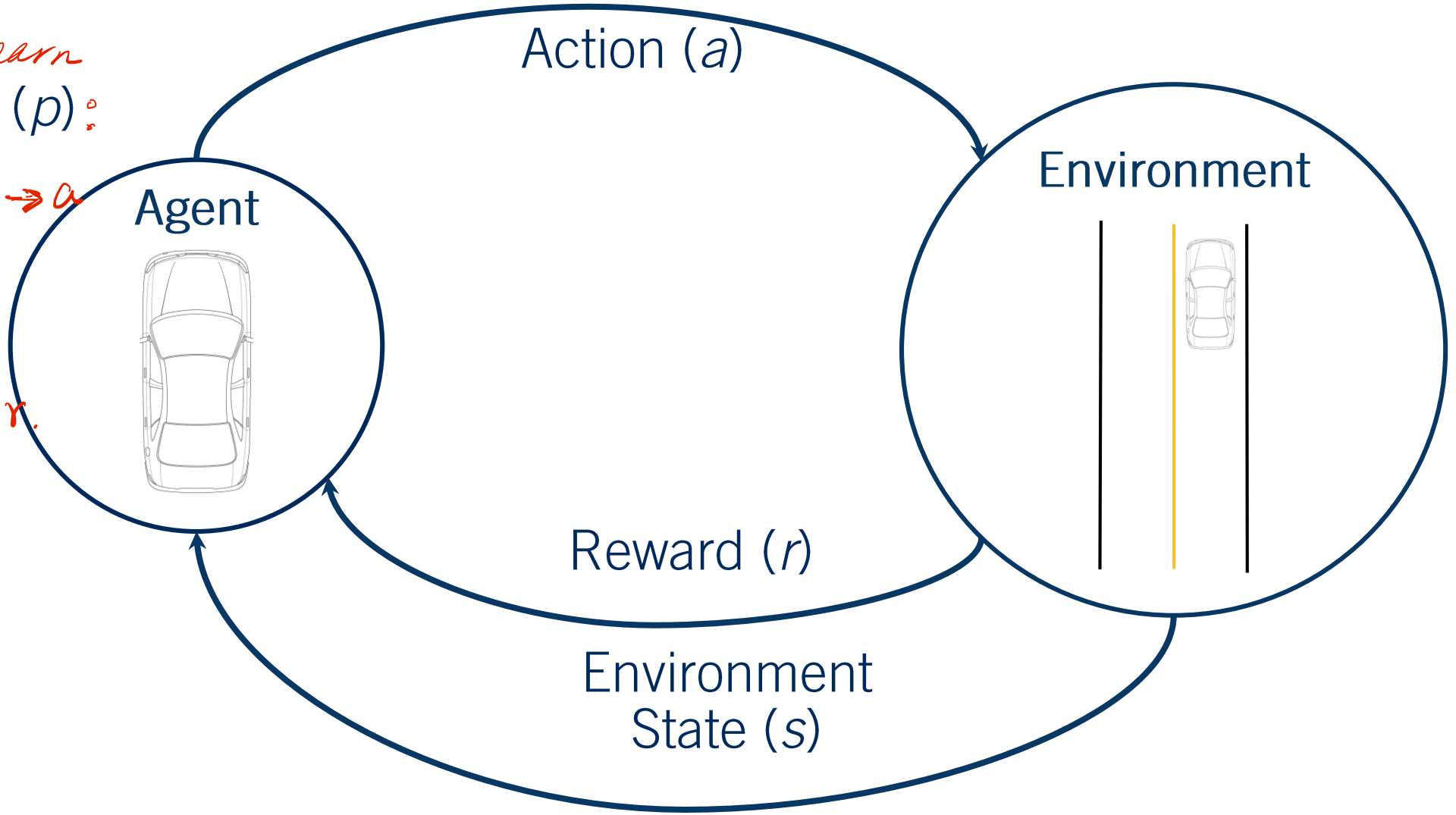

Fuzzy logic:



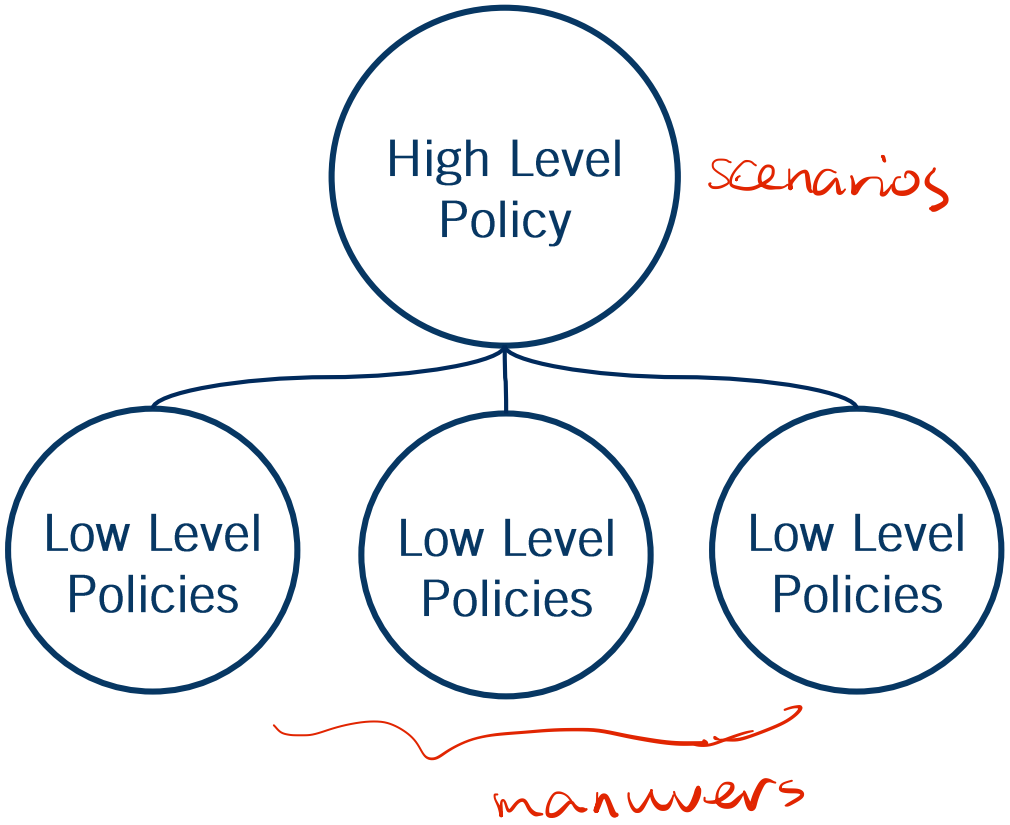
# Reinforcement Learning

To learn
Policy ($p$):
map $s \rightarrow a$
given
reward
function $r$.

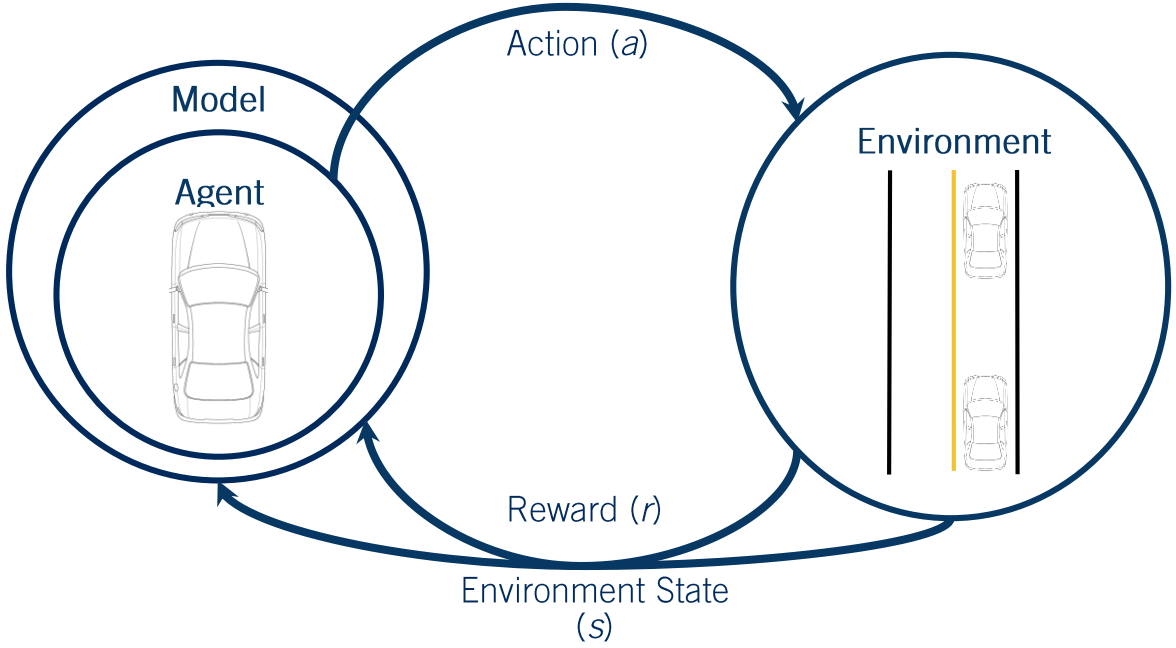


# Reinforcement Learning

## Hierarchical Reinforcement Learning




## Model-based Reinforcement Learning



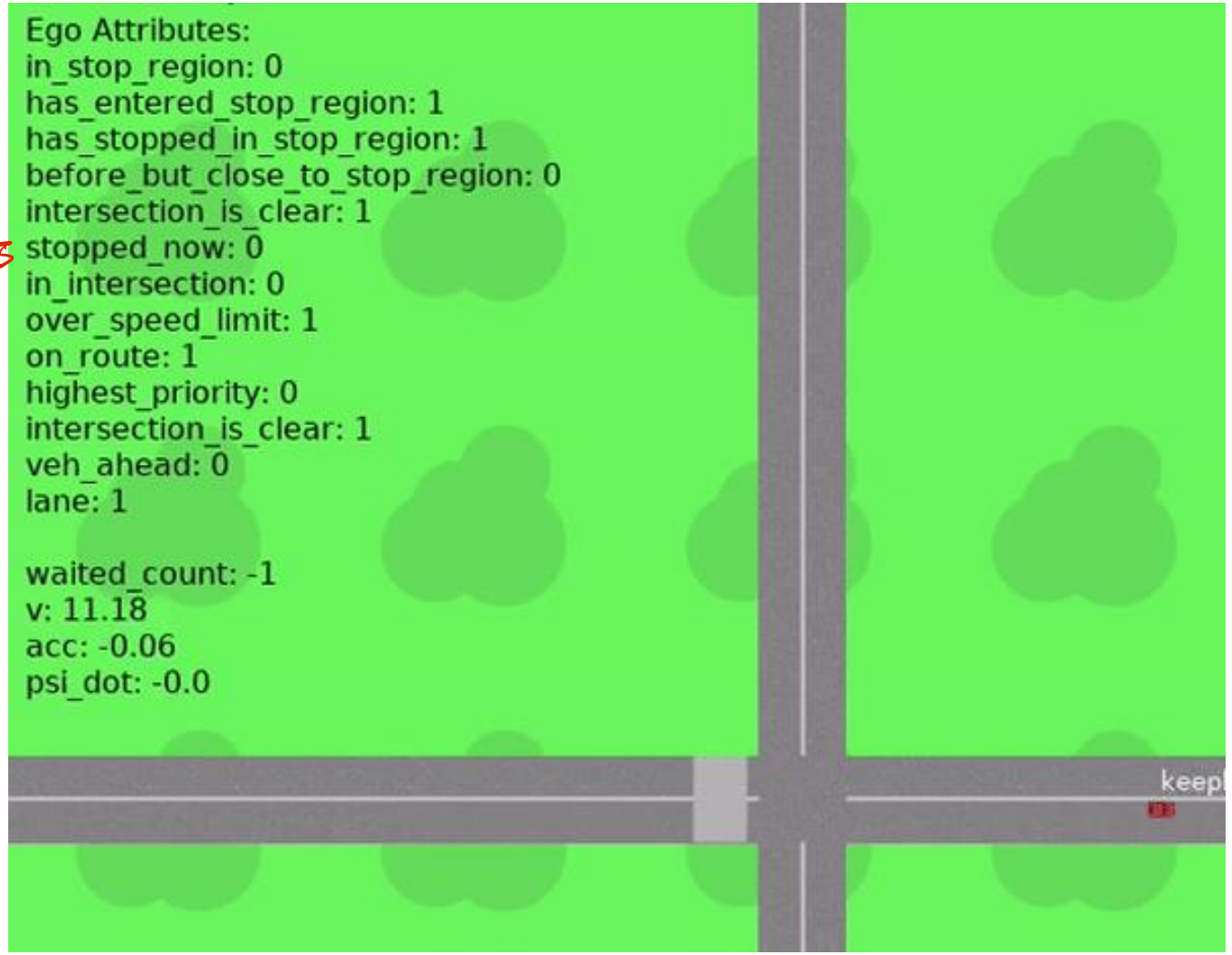
# Reinforcement Learning Issues

- Simple Simulation Environments

may not be transferrable to real world environments

- Ensuring Safety

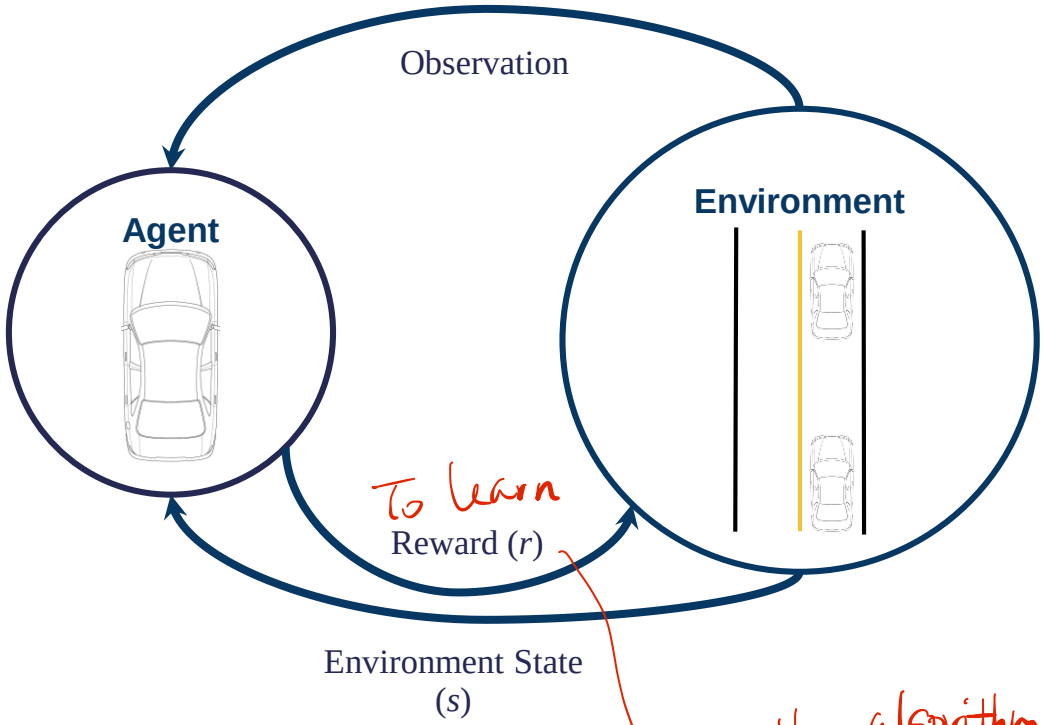
no rigorous safety assessment.



# Machine Learning

Behavior planning bottleneck:
achieving real world level 5 autonomy.

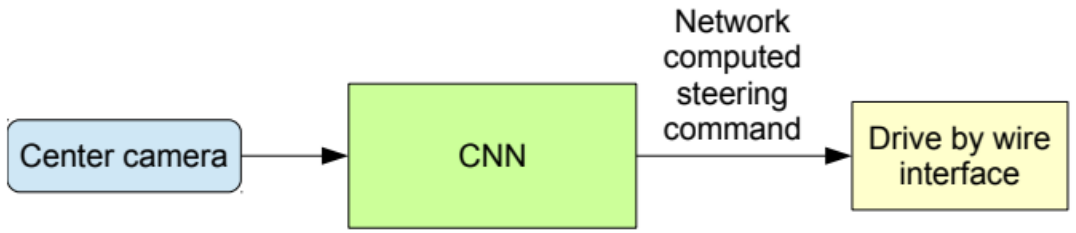
## Inverse Reinforcement Learning




To learn

after that, the algorithm can execute driving maneuvers similarly to a human driver.

## End-to-End Approaches

# Summary

- Identify issues with the state machine based behaviour planner
- Identify the open areas of research in behaviour planning

- **Next**: Building a full local planning solution