Control of mixed autonomous vehicle-infrastructure in a heterogeneous multi-agent system framework

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Motivation

- UK is keen to roll out autonomous vehicles (AVs) on roads by 2025 with the support of new government plans and £100 million [1]
- Prevalence of CAVs is expected
- Traffic management strategy and infrastructure are needed to coordinate the disordered transportation system

Challenges – Mixed Autonomy

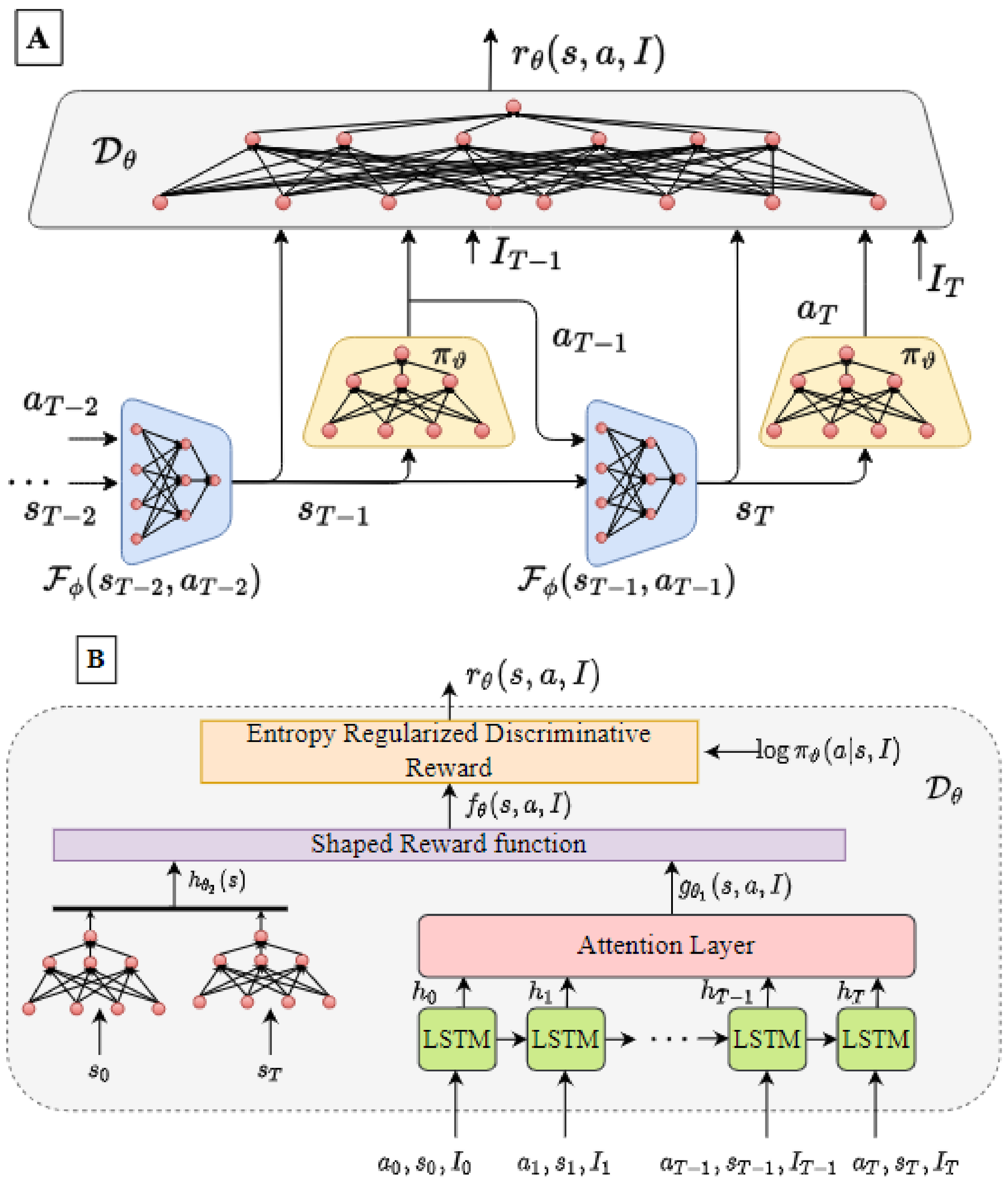
- AVs and human-driven vehicles co-exist
- How should AVs behave?
- How does infrastructure adapt to AVs?

Potential Issues

- Traffic efficiency
- Human-driven vehicles bullying
- Unethical autonomous driving

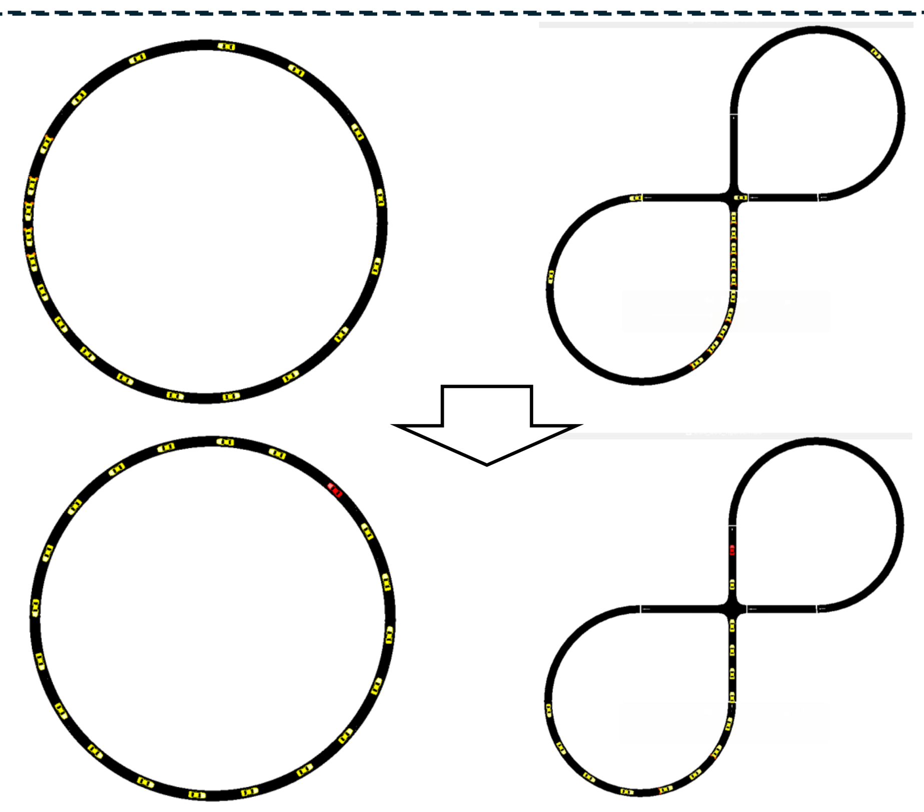
Driver Intention Recognition

- Understanding human driving intention for AVs control
- Classification problem:
  - scenes + action -> intention
- Indeed, human decision-making:
  - scenes + intention -> action
- Proposed inverse reinforcement learning-based intention inference method [2]
  - Accuracy increased by 6.2%



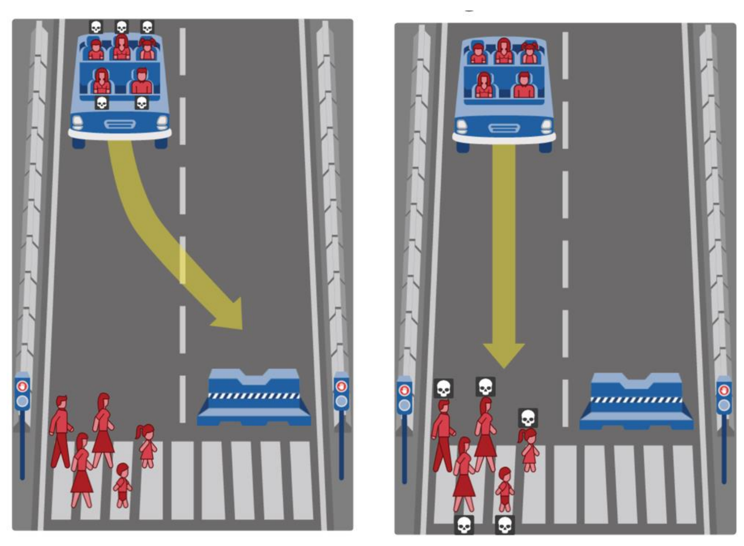
Mixed Autonomy Control

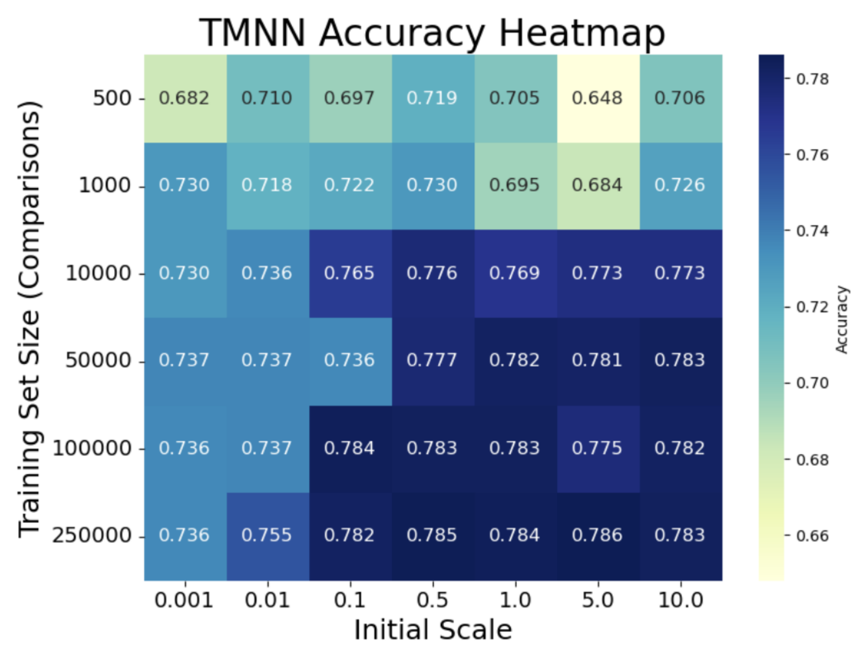
- Traffic shockwave emerge in a vehicle fleet
- To control AVs in the vehicle fleet to attenuate traffic shockwave and congestion
- Increased 22% traffic flow
- Reduced 23% emissions [3]

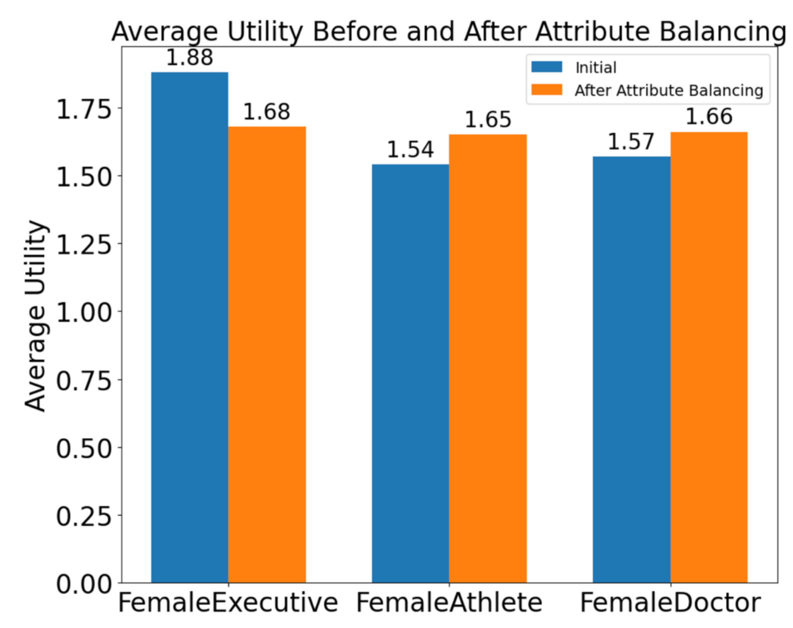


Moral Decision-Making

- Existing studies focus on binary moral scenarios like trolley problem
  - Can handle binary scenario only
  - Inherent unwanted human bias
- Proposed Thurstone-Mosteller Additive Neural Network [4]
- Able to disentangle the learned moral utility of the binary dataset to deal with complex moral scenario
- Mitigate human bias while following human preferences and compiles with regulation for sensitive attributes







Hybrid Safe Control

- Hybrid safe control approaches
  - Generalizable within defined boundaries
- Proposed a neural control barrier function [5]
  - Achieve safety by learning state transition
  - Do not need a mathematical model

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References

[1]: HM Government, "Connected & Automated Mobility 2025: Realising the benefits of self-driving vehicles in the UK," 2022.

[2]: K.-F. Chu, et al., "Explainable Adversarial Inverse Reinforcement Learning for Driver Intention Recognition," under review.

[3]: K.-F. Chu, et al., "Reservoir Computing-Based Control of Traffic Emergent Behaviour," under review.

[4]: C. Fan, K.-F. Chu, et al., "State Transition Learning with Limited Data for Safe Control of Switched Nonlinear Systems," Neural Networks, vol. 180, Dec 2024.

[5]: K.-F. Chu, et al., "Fair Risk Allocation in Autonomous Driving via Disentangled Moral Utility Estimation," under review.