

# Quantum Reinforcement Learning in Trackmania

## Hybrid classical-quantum reinforcement learning system to train an AI in a racing game

Prajesh Panjiyar, Abdul Majid, Ahmed Khaled, Lien Bradley

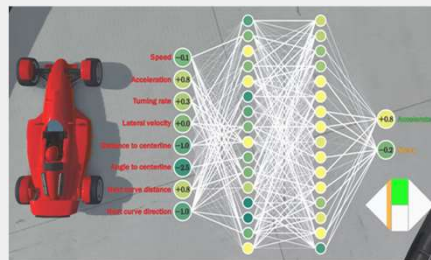
### Motivation and Goal

How can Quantum be used to improve reinforcement learning?

**Goal:**

- Design and simulate a hybrid classical-quantum reinforcement learning framework.
- Demonstrate that quantum models achieve performance comparable to classical approaches.

Reinforcement Learning trains an AI agent via trial-and-error feedback:  
 observation → action → reward → repeat



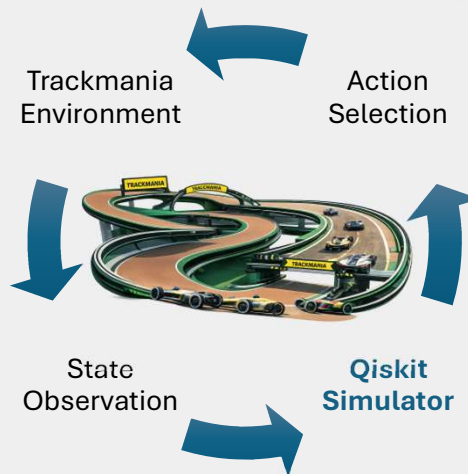
### Background

- Classical neural networks may struggle to efficiently capture complex nonlinear interactions between speed, steering, and track geometry.
- Hybrid quantum-classical feature representations offer a promising way to improve expressiveness and generalization without increasing network depth or training data.

### System Overview

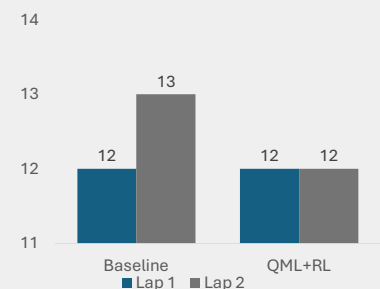
How does the hybrid system work?

- Classical RL loop observes the environment and selects actions.
- Quantum model influences actions choices by processing states using parameterized quantum circuit.
- Actions are selected based on the quantum model's output by sampling from a probability distribution.



### Expected Performance

Comparison of average lap times between the classical baseline and the hybrid QML+RL approach across multiple runs.



### Potential Challenges

- Lack of readily available QRL algorithms to test and compare.
- Limitation of classical system to simulate large number of qubits.

### Key Takeaways

- Hybrid QML-RL system conceptually feasible in simulation.
- Game serves as interpretable testbeds for quantum machine learning

### Future Work

- Full implementation and benchmarking.
- Porting to RasQberry 2 system.
- Optimizing QML models for complex tasks.

### References

<https://store.steampowered.com/app/2225070/Trackmania/>  
<https://www.theautopian.com/how-a-youtuber-spent-years-teaching-ai-how-to-beat-him-at-virtual-racing>  
<https://github.com/JanLahmann/RasQberry-Two/issues/186>