APPLICATION OF REINFORCEMENT LEARNING ALGORITHMS FOR FORMULA ONE F1 VEHICLE FOR ROUTE EFFICIENCY

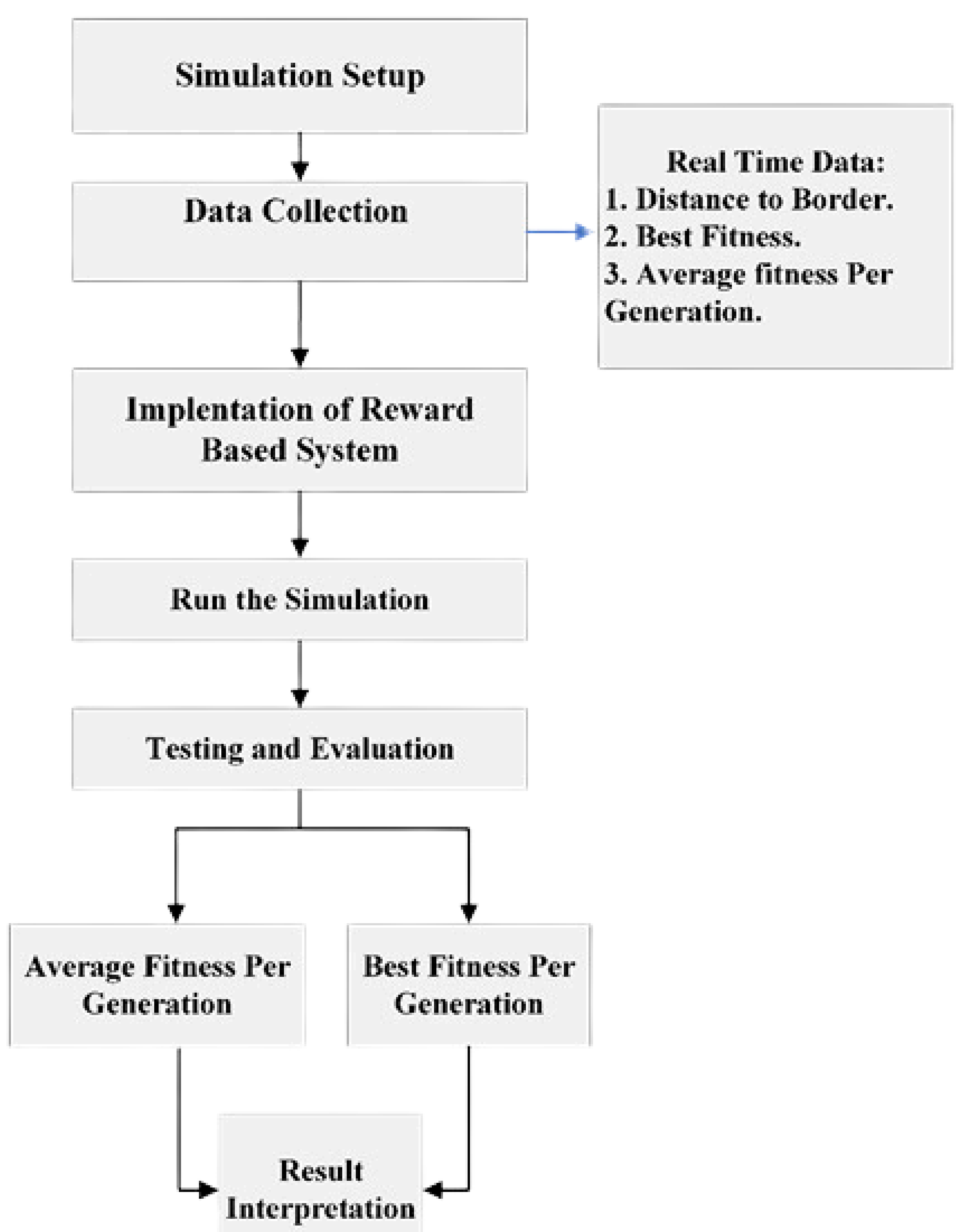
MUHAMMAD TAIMOOR KHAN* (20BSCS045), MUHAMMAD HAMZA (20BSCS011)

INTRODUCTION

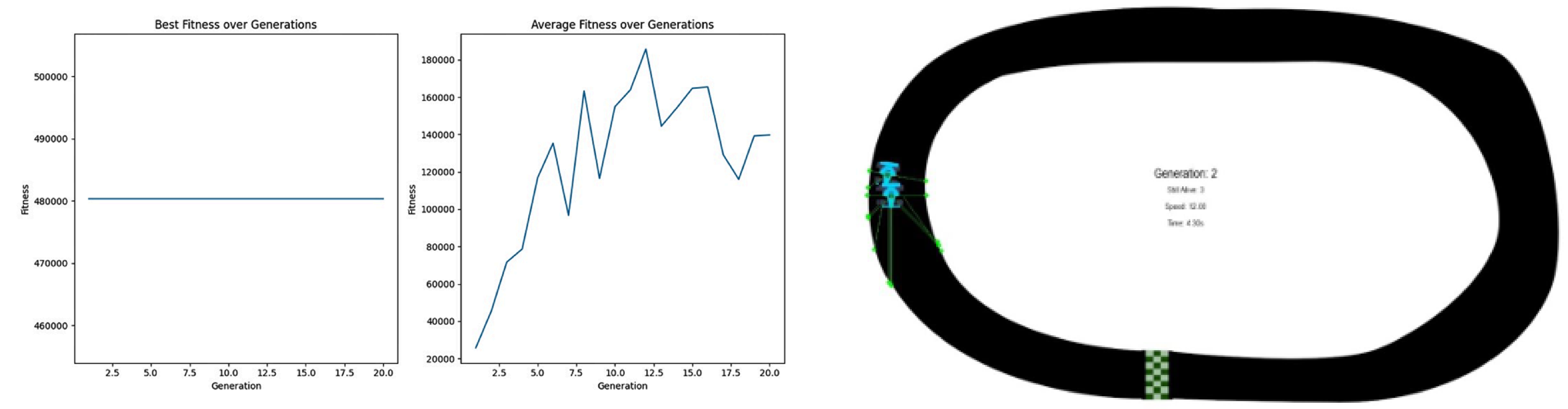
Reinforcement Learning (RL) focuses on maximizing cumulative rewards through experience-based learning, allowing agents to navigate uncertain environments by making decisions based on feedback.

- Challenges such as **complex racing environments**, real-time decision-making, and balancing exploration with exploitation persist.
- This study employs a simulation using the **NEAT** algorithm to train an autonomous F1 car, utilizing real-time **sensor data** and **PyGame** for graphical evaluation of navigation capabilities.

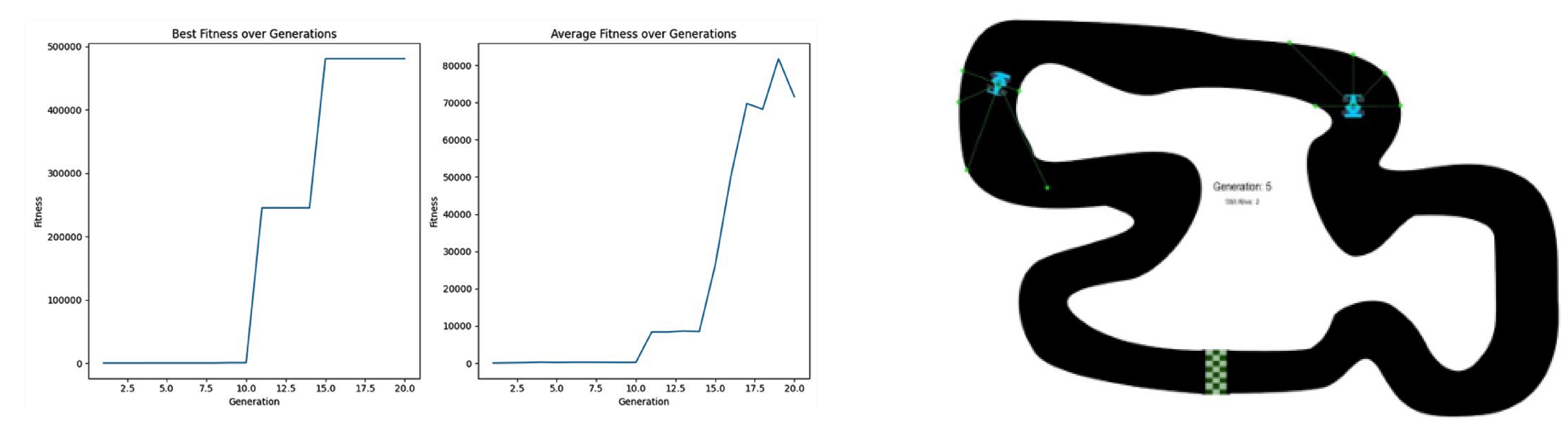
METHODOLOGY



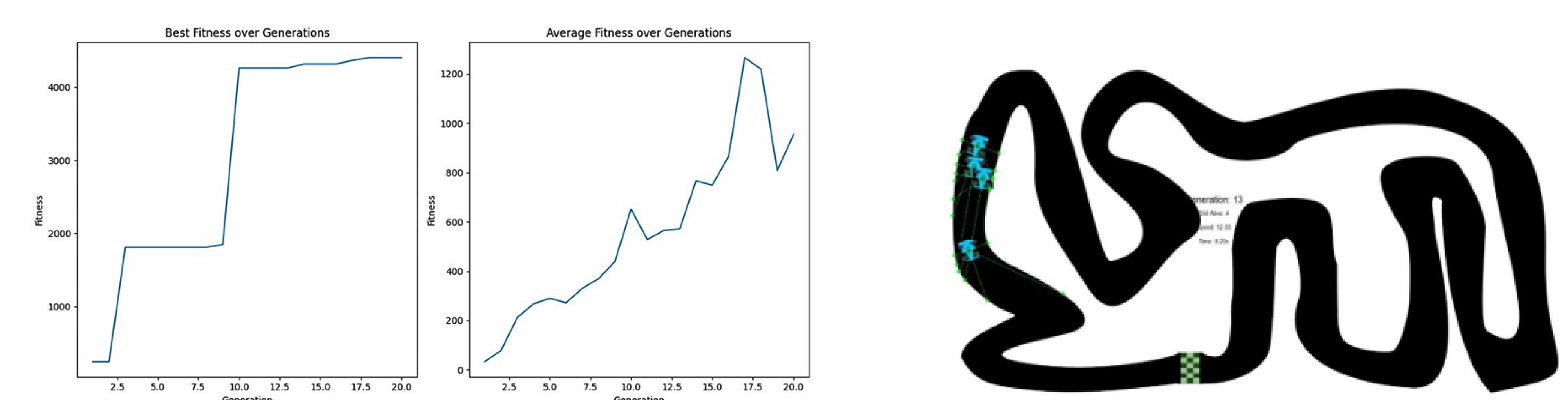
RESULTS AND ANALYSIS



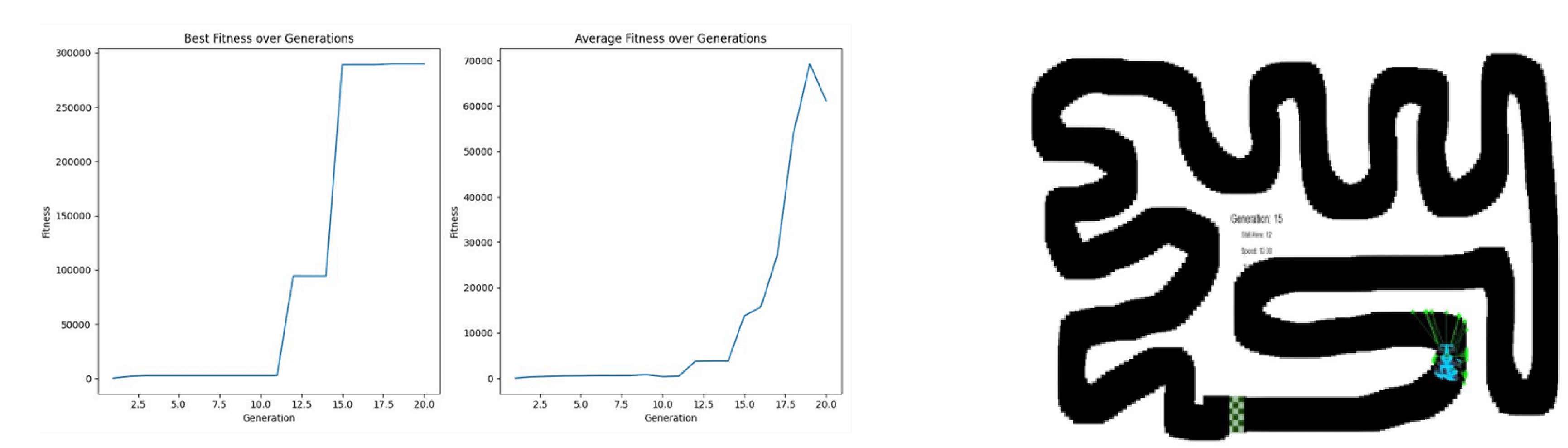
In Map 1, we see steady fitness gains indicate successful learning.



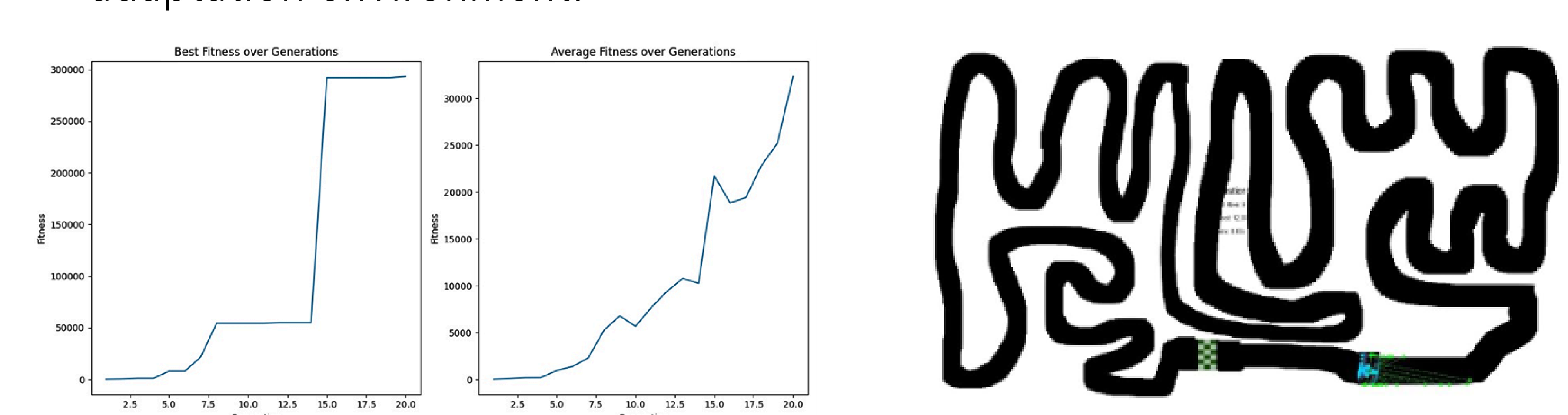
In map 2, we observe some plateaus, breakthroughs, but limited fitness gains.



In map 3, some plateaus and lower fitness indicate tougher adaptation.



In map 4, number of plateaus and lower fitness show toughest adaptation environment.



In map 5, plateaus with slight gains show gradual adaptation struggles.

LIMITATIONS & FUTURE WORK

This study has several limitations:

- The simulation may not fully reflect real-world racing complexities.
- NEAT's performance may benefit from alternative architectures and hyperparameter tuning.
- Dependence on sensor data could limit adaptability in unpredictable situations.

Future work includes:

- Expanding simulations to include varied terrains and dynamic obstacles.
- Exploring advanced techniques like transfer learning and multi-agent systems.
- Enhancing real-time decision-making capabilities for practical autonomous driving applications.

CONCLUSION

- This research demonstrates reinforcement learning's application using the NEAT algorithm for autonomous F1 car navigation in a simulation.
- Results indicate that reinforcement learning enhances decision-making and adaptive learning in dynamic racing scenarios.
- Over generations, fitness scores consistently improved, reflecting refined strategies for obstacle avoidance and route optimization.

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