Evolutionary Methods in Collective Herding Systems

Overview

This project extended a 2D **sheep-herding** multi-agent system, where dog agents herd sheep into a target zone. We investigated the effectiveness of **hybrid** evolutionary methods in **dynamic** environments and compared the performance of agents with **fixed** versus **evolving morphologies** as environmental **complexity increased**.

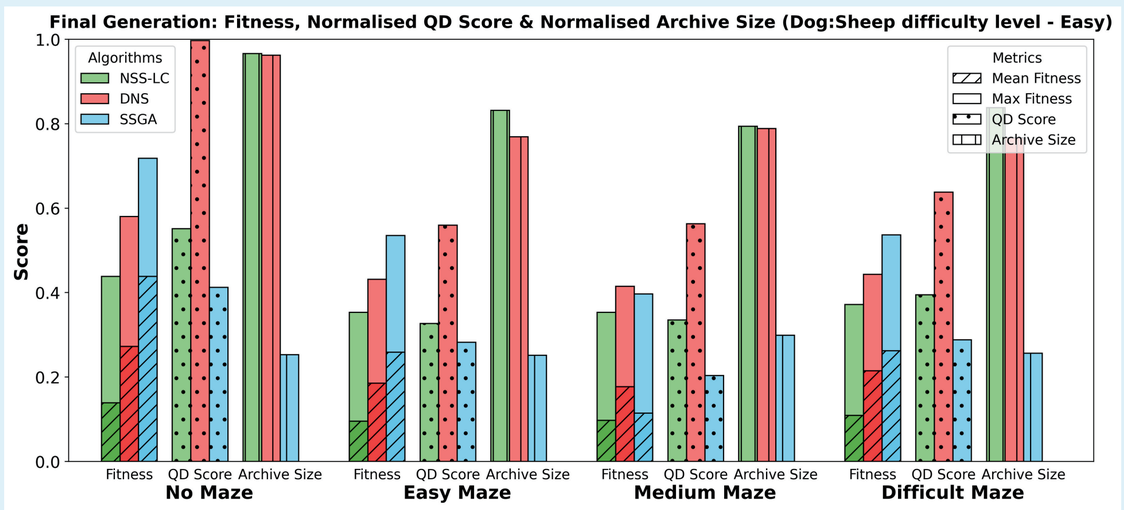
Hybrid Methods in Dynamic Environments

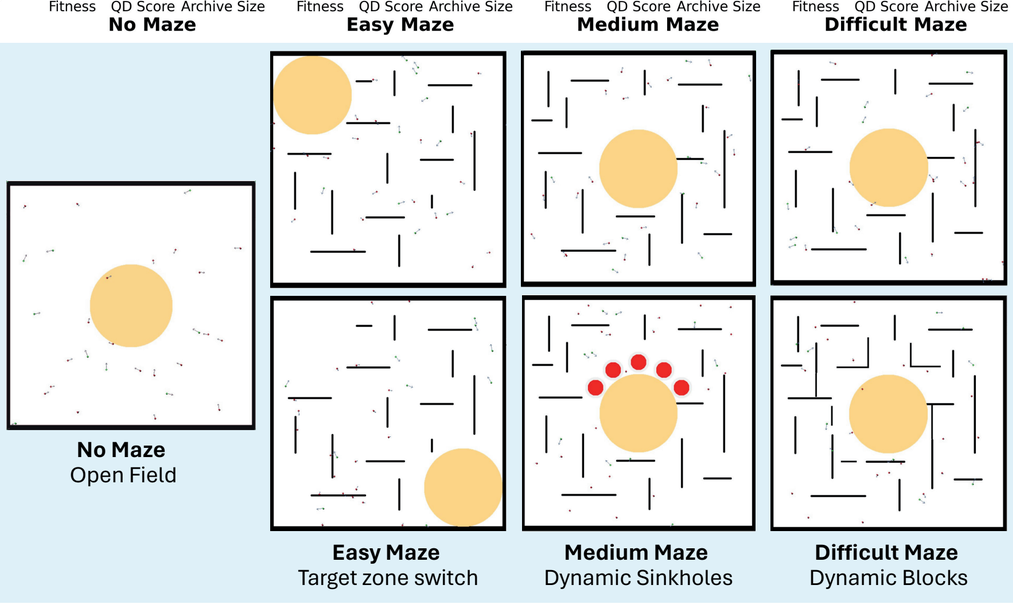
Objective

This study compared two hybrid evolutionary algorithms, Novelty-Surprise Search with Local Competition (**NSS-LC**) and Dominated Novelty Search (**DNS**), and the objective-based Steady-State Genetic Algorithm (**SSGA**) on a sheep-herding task in increasingly complex dynamic maze environments. Performance was evaluated in terms of **exploitation** (sheep captured) and **exploration** (solution diversity) to investigate which algorithm achieved the ideal **exploration-exploitation** balance.

Results and Conclusion

SSGA performed best in exploitation in most environments, whereas **DNS** outperformed **SSGA** in exploration across all cases. **DNS** also achieved the highest mean fitness on the complex Medium Maze and outperformed **NSS-LC** in 3 of 4 metrics, achieving the ideal **exploration-exploitation** balance overall. These results suggest **exploitation-only** methods (**SSGA**) are more effective in **simpler** environments, whereas, **hybrid** methods (like **DNS)**, may be more effective in sufficiently **complex, dynamic** environments, as in the real world.





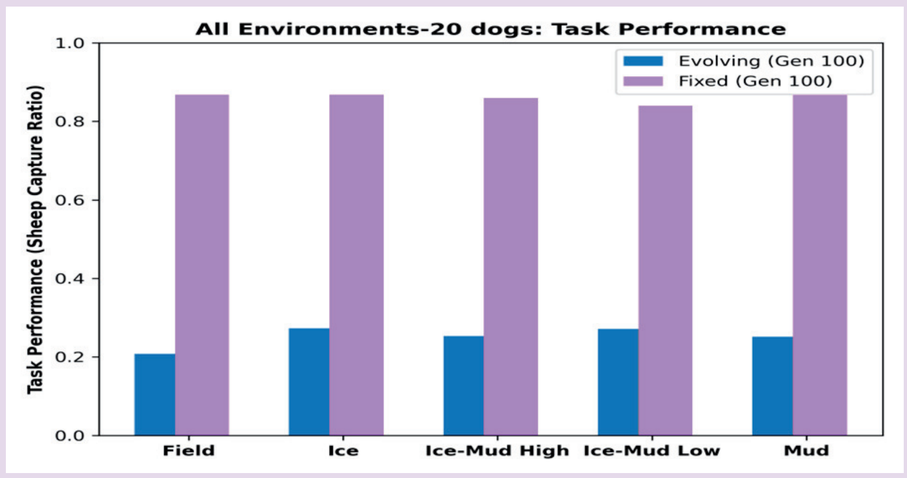
Body-Brain Evolution

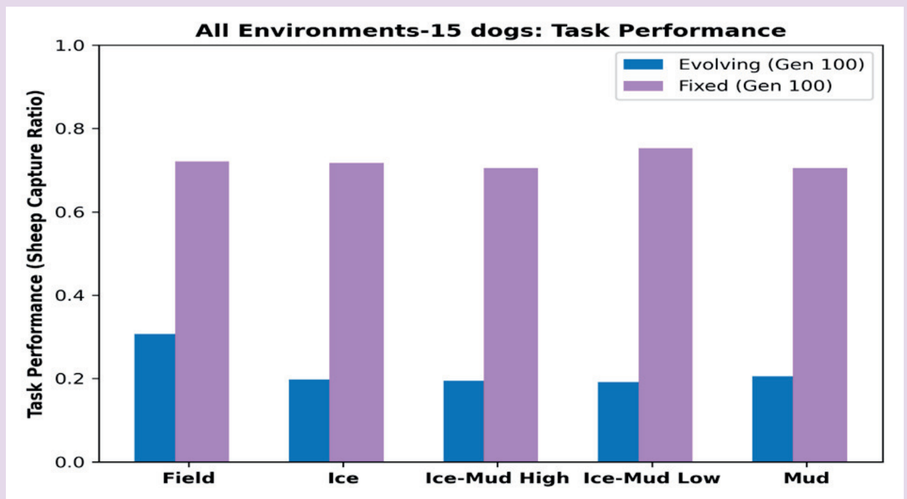
Objective

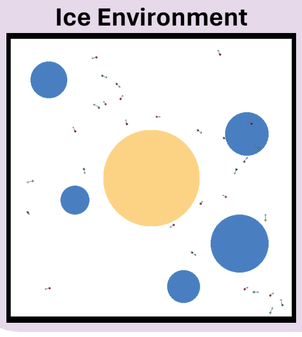
This study used a simulated herding task in environments with varying terrain as a case study to explore the impact of **environmental complexity** on the **body-brain evolution** of herding agents, and to investigate the effectiveness of simultaneous body-brain evolution in improving the **performance** of the multi-agent system across environments with **varying terrain**.

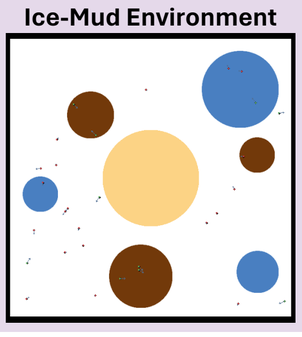
Results and Conclusion

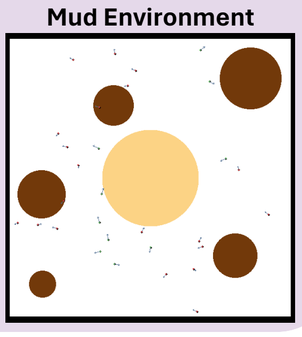
It was found that **evolutionary morphology** did not translate into improved task **performance**. **Fixed morphologies** consistently performed **better** across all environments and swarm sizes. Fixed agents reached **significantly higher** sheep capture rates of 70-90%, while evolving agents plateaued at 20-30%. The results imply that **evolution** favoured **complex body** designs, but this did not translate into better performance.






Ice Environment


Ice-Mud Environment


Mud Environment

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