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Using Internal States and Swarming Behaviours to Enhance the Performance of Swarm Robots

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Swarm robots?! What do you mean?

Fig. 1 100 robot swarm during navigation (MIT, CSAIL)

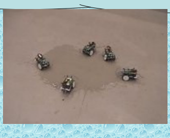

Fig. 2 Swarm of robots finds an area of interest (INL)

Swarm robotic systems are teams of identical robots that have high rates of information exchange among the individuals. They have wide range of applications from seeking for survivors in an earthquake site to planet exploration.

Right, so what is the problem?

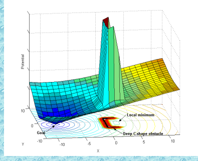

Fig. 3 Deep local minimum forms behind a deep C-shape obstacle

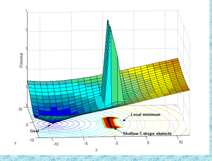

Fig. 4 Shallow local minimum forms behind a shallow C-shape obstacle

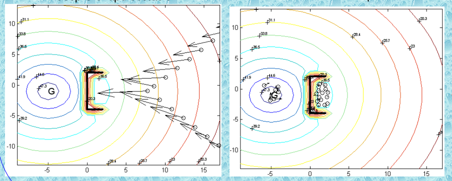

Fig. 5 Behaviour of a conventional swarm of agents with fixed internal states

To make path-planning for these systems, a computationally simple method is needed especially for increasing number of constituents. The conventional artificial potential field method is suitable. However, this method has a fatal disadvantage which is the local minima formation. Previous attempts to solve the problem are either computationally expensive and then not suitable for real applications or works for easy types of local minima.

Oh! So what's in your mind?

Fig. 6 In nature we can see a flock of birds follow a leader, a colony of bees aggregates to beat an intruder and a fish school provides a milling pattern

Inspiring ideas from swarming behaviour in natural systems to enhance the performance of the swarm robots.

Really! Have you succeed?

Swarm leader:

When one of the agents have clear way to the goal it has higher attraction potential then become temporarily leader to the other individuals of the swarm.

Swarm aggregation:

When a Part of the swarm is repelled the entire swarm aggregate to face the problem as a flock to reduce the opportunity of leaving some agents stuck in the trap.

Emergent-like behaviour:

Using the swarm center velocity to increase the swarm members' perception about the environment enables the swarm to effectively follow the obstacle wall boundaries by activating pure rolling motion of the vortex pattern into which the agents self-organize .

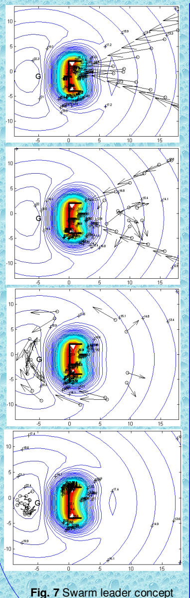

Fig. 7 Swarm leader concept

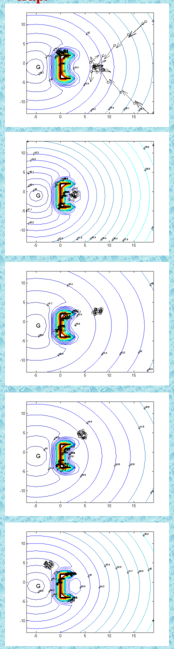

Fig. 8 Swarm aggregation concept

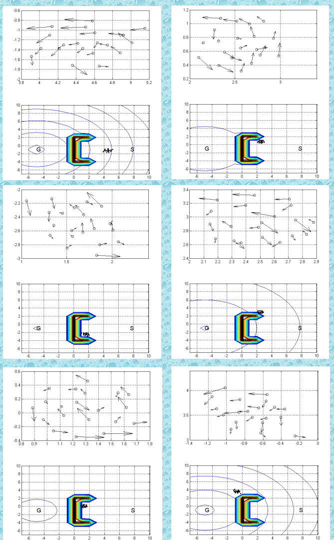

Fig. 9 Emergent-like concept

Great. No doubt this work has useful applications. Can you use it to solve mazes?

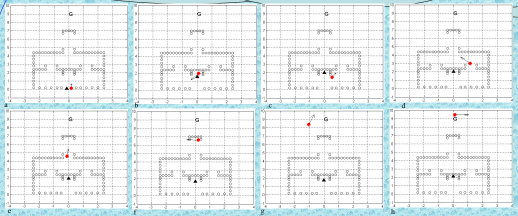

Fig. 10 Maze application for a single agent using the internal state model dynamic potential (●), and that with static potential (▲)

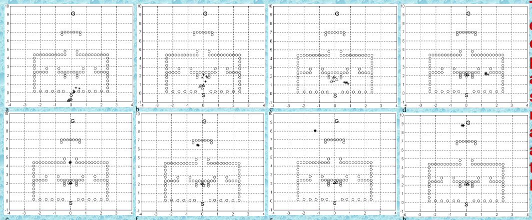

Fig. 11 Maze application for agents using the internal state model; (*), and those with a static potential; (Δ)

The work presented enables to solve complicated path-planning problems such as Multi-level mazes for single robot, swarm of robots using the swarm aggregation concept and swarm of robots that use the emergent-like behaviour.

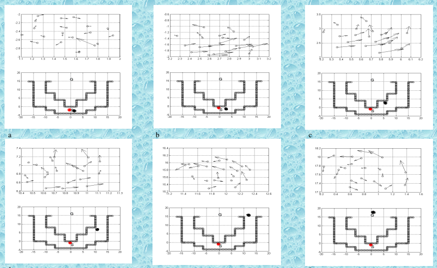

Fig. 12 Maze application for agents using the emergent-like model

How clever. I am sure this work contributes to robotic field.

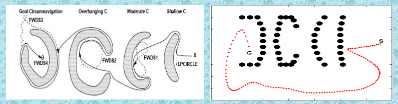

Fig. 13 Performance comparison test

Performance comparison tests prove that the method is more efficient than the most updated way to solve the local minimum problem for robot navigation; Forward chaining.

But wait a minute. I don't believe that these ideas can be used for real robots.

Fig. 14. Swarm leader concept implementation

Fig. 15 One of the used robots

Of course it can. A 'rescue' mission application using the swarm leader concept is successfully implemented in a swarming behaviour test-bed; *University of Strathclyde*. The test-bed has been built to test the behaviour of identical robots, which interact via pair-wise interactions.

Conclusions please. For the files.

New potential field method has been presented which uses the concept of an agent internal state along with the swarming behaviour to allow agents to manipulate the potential field in which they manoeuvre. The method allows a swarm of agents to escape from and manoeuvre around a local minimum in the potential field to reach a goal regardless of the formed local minima in the global potential. Simulation results and implementations confirm the efficiency and applicability of the new method.

Do you have publications in specialized international conferences?

- **Mabrouk M. and McInnes C. (2007). Swarm robot social potential fields with internal agent dynamics. In Proceeding of the 12th International Conference on Aerospace Sciences & Aviation Technology (ASAT12), ROB-02:1-14.**
- **Mabrouk M. and McInnes C. (2008a). Social potential model to simulate emergent behaviour for swarm robots. Accepted by the 13th International Conference on Applied Mechanics and Mechanical Engineering, AMME-13.**
- **Mabrouk M. and McInnes C. (2008b). Wall following to escape local minima for swarms of agents using internal states and emergent behaviour. Accepted by the International Conference on Computational Intelligence and Intelligent Systems, ICCIIS 2008. (Nominated for best paper prize, nominated to be included as a chapter of a book about state of the art in swarm robots).**