Dynamic trust consensus for cooperative tracker using potential field approach

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Introduction

This paper evaluates the feasibility of using trust consensus to exclude robots that have malfunctions or get stuck between obstacles while navigating to the target using the potential field approach. Two algorithms for cooperative motion with the presence of a leader are proposed and evaluated. An algorithm to determine trust dynamically at each step is proposed and tested.

Methodology and Setup

Motion of unmanned vehicle swarms in extreme conditions can cause unit malfunctions. We have here considered a trust consensus in conjunction with potential fields of obstacles and targets to guide the motion of the swarm, maintaining formation and accounting for compromised units.

Scenarios for swarm movement within an environment with known potential fields have been presented for a star formation. Approaches for best formation strategy has been worked towards.

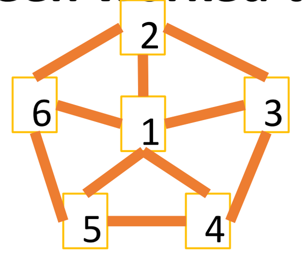


Fig 1. Star with extra edges Structure

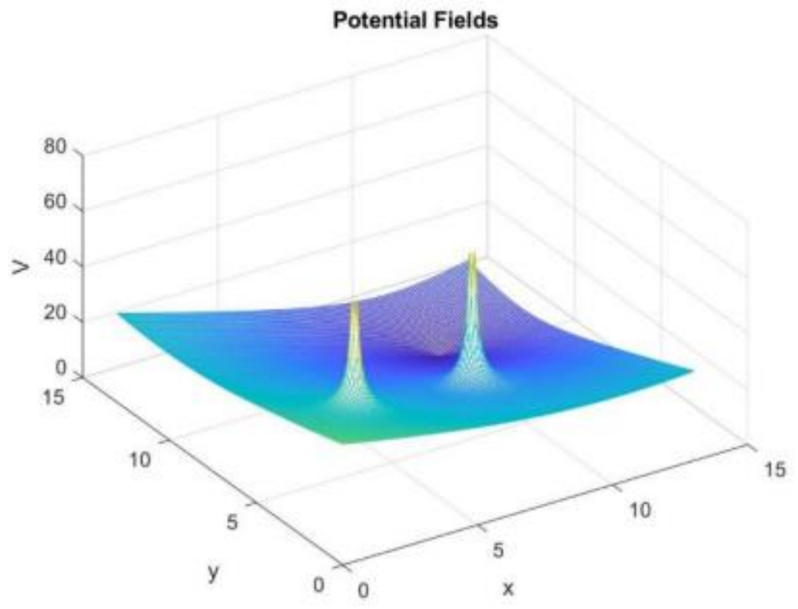


Fig 2. Obstacle and Target Potential Field

Experimental Test Plan

- Define node positions for the system and define the target location.
- Define positive initial trust consensus values between nodes and create algorithm for convergence to target.
- Simulate with negative trust for one of the nodes in the system, abandon node with negative trust.

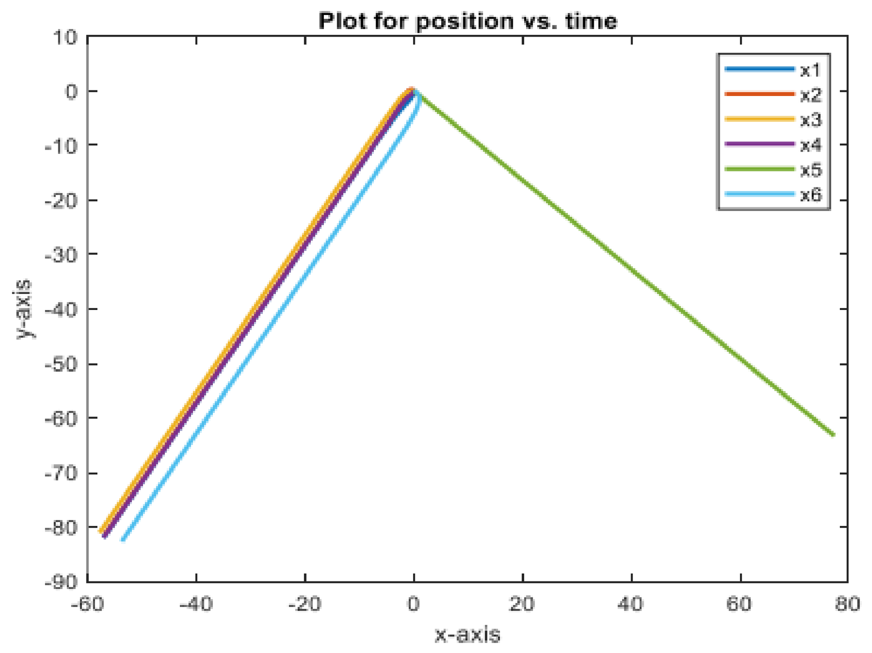


Fig 3. Positional Movement Using Potential Field

- Create control system for system with leader node input using θ consensus and positions $[x, y]$ consensus as input amongst nodes.

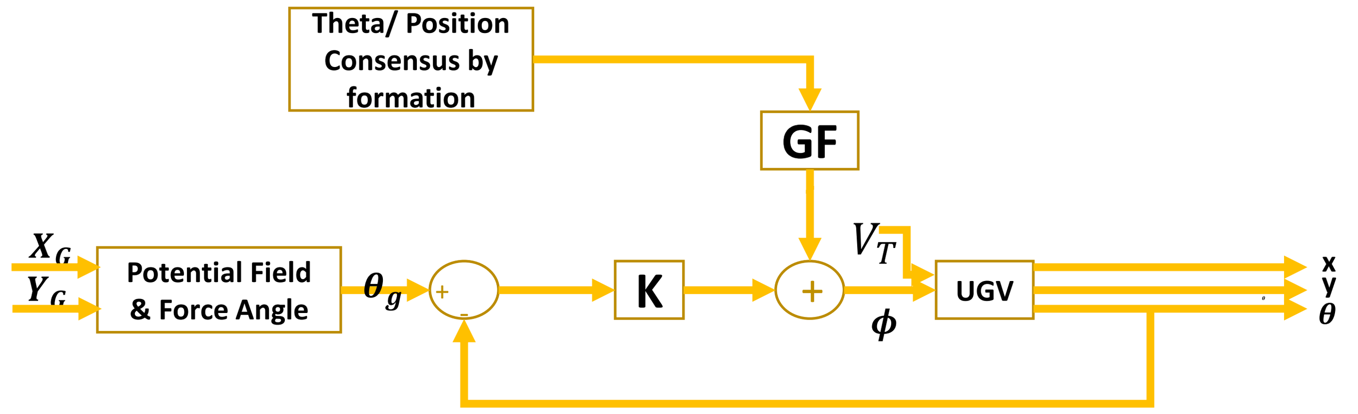
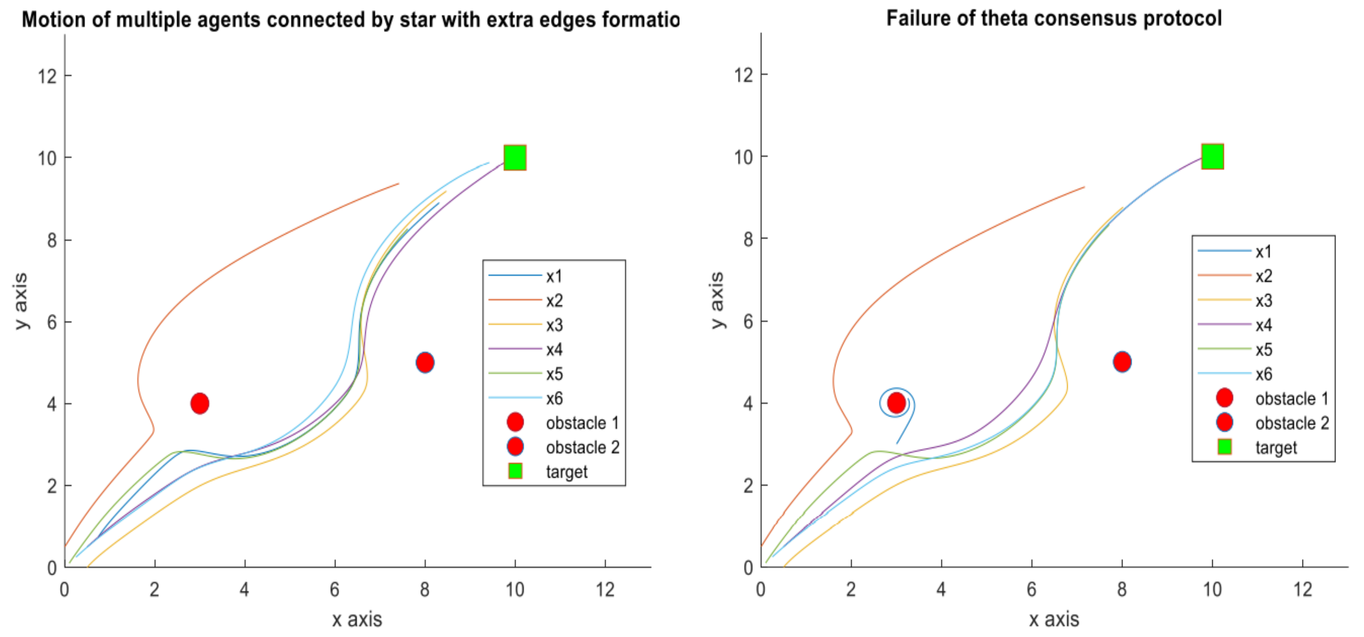


Fig 4. Controller Algorithm for UGV Motion for θ or position consensus

- Derive system simulation with leader position close and far from the obstacle thus creating variation in system trust consensus between nodes and leaders.
- Comparative analysis between θ and positional consensus system done.
- Ddetermine dynamic trust values at each step and use trust consensus to determine if a node is stuck. If a node is stuck and then it's cut off from the formation and it moves to the target using the potential field.
- Results discussed and conclusions drawn on positional and θ consensus methodology.

Results

- System conditions have been varied from, random node heading without and with follower, inclusion of controller in the system, theta trust consensus and positional trust consensus in the system.
- It is observed that position consensus is the more robust approach.



Independent consensus trust motion of nodes and failure of θ mode consensus

Fig 5. Node motion for θ consensus protocol

Multiple node and leader follower position trust consensus movement of nodes in x-y plane.

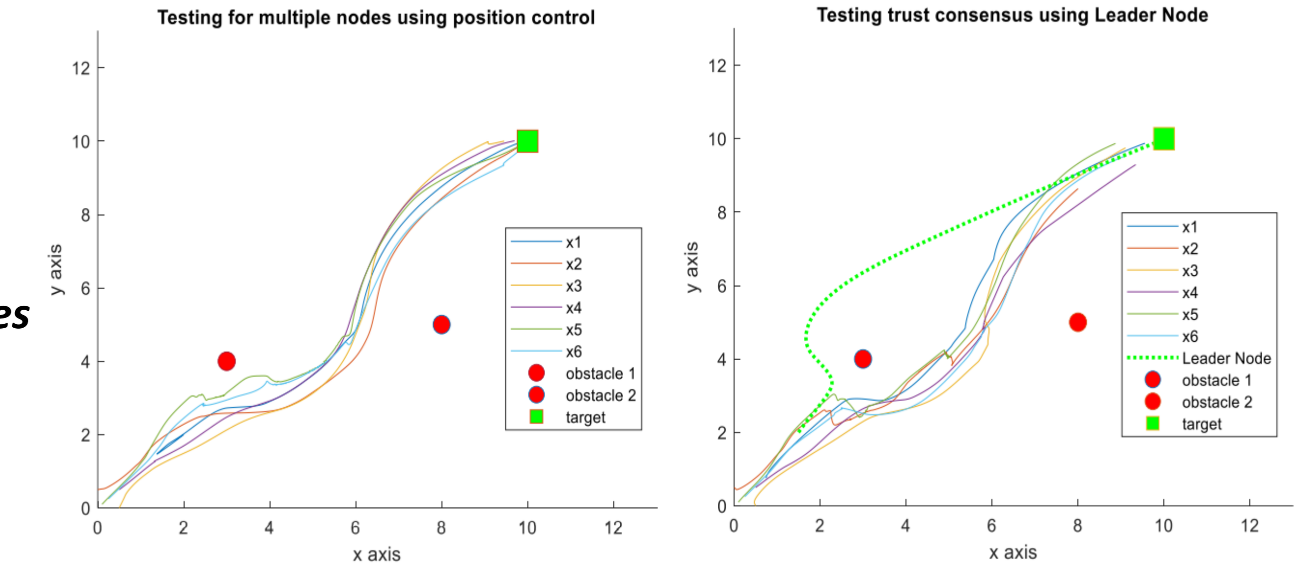


Fig 6. Node motion for position consensus protocol

Discussion and Conclusion

- Based on different algorithms, it was observed that application of a leader node along with trust consensus significantly increases the reliability of a formation structure to reach its goal within a potential field. To avoid the cut-off of many nodes towards the end, a simple reset algorithm can be implemented for the L matrix so that nodes can rejoin the structure if they are moving towards the same point.
- Further improvements include dynamic graphs for formations where a specific type of formation is desired position wise. The trust consensus can be further modified by reducing the step sizes and even normalizing the deviation from the average of the position of other nodes.

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