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Trust-Aware Behavior Reflection for Robot Swarm Self-Healing

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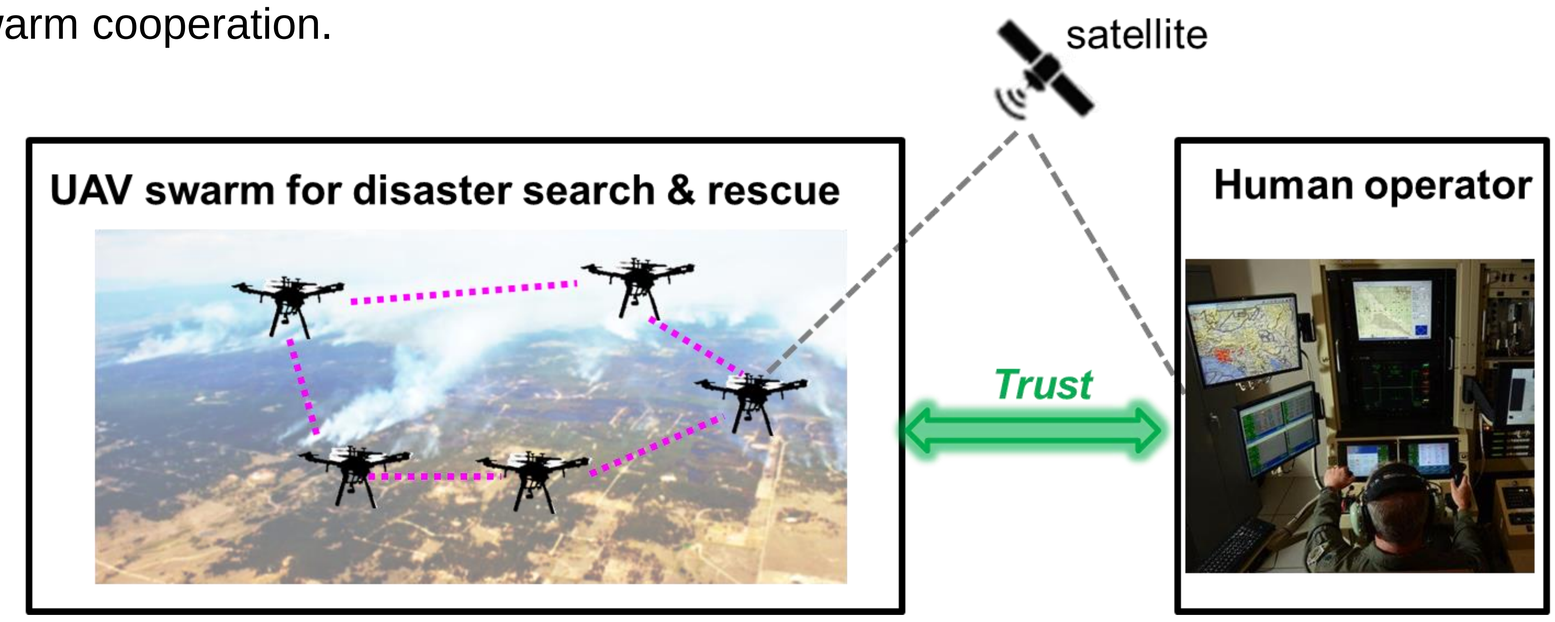
Motivation

The deployment of robot swarms is influenced by real-world factors, such as motor issues, sensor failure, and wind disturbances. These factors cause the appearance of faulty robots. In a decentralized swarm, sharing incorrect information from faulty robots will lead to undesired swarm behaviors, such as swarm disconnection and incorrect heading directions. We envision a system where a human operator is exerting supervisory control over a remote swarm by indicating changes in trust to the swarm via a "trust-signal". By correcting faulty behaviors, trust between the human and the swarm is maintained to facilitate human-swarm cooperation.



Challenge

UAVs are influenced by real-world factors

2018 July, USA. wind disturbance

2018 May, Xi'an China. GPS localization failure.

Real-world factors
-wind disturbance
-robot motor wear
-sensor/sys uncertainty

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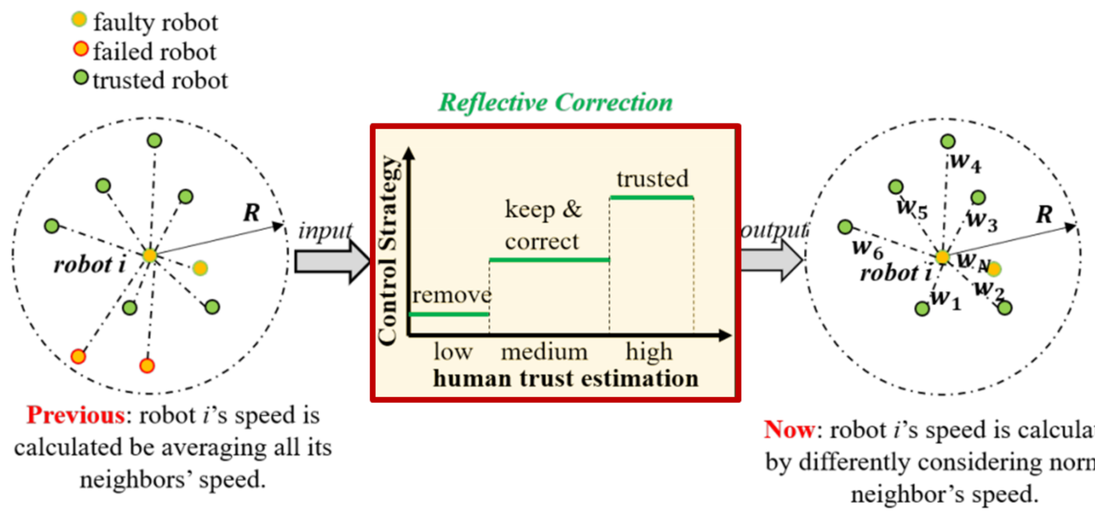
Untrusted Behaviors
-UAV disconnection
-slow speed
-wrong heading direction

Method

Robots have self-awareness of human expectation, to reduce the communications with untrusted robots and to increase the communication with trusted robots.

Trust-Aware Behavior Reflection Method – ***Trust-R***



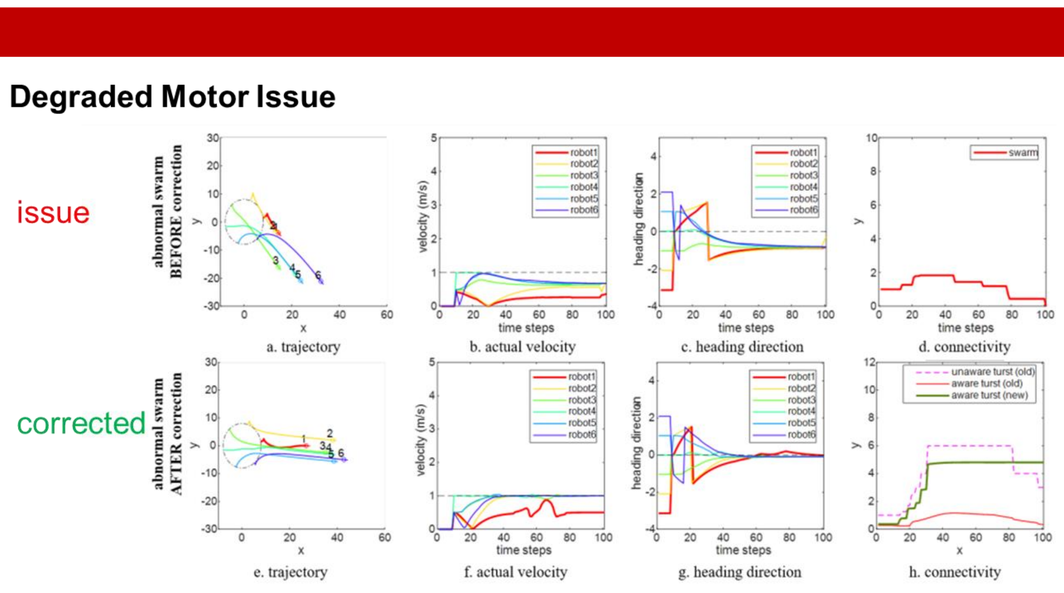
Previous: robot *i*'s speed is calculated be averaging all its neighbors' speed.

Now: robot *i*'s speed is calculated by differently considering normal neighbor's speed.

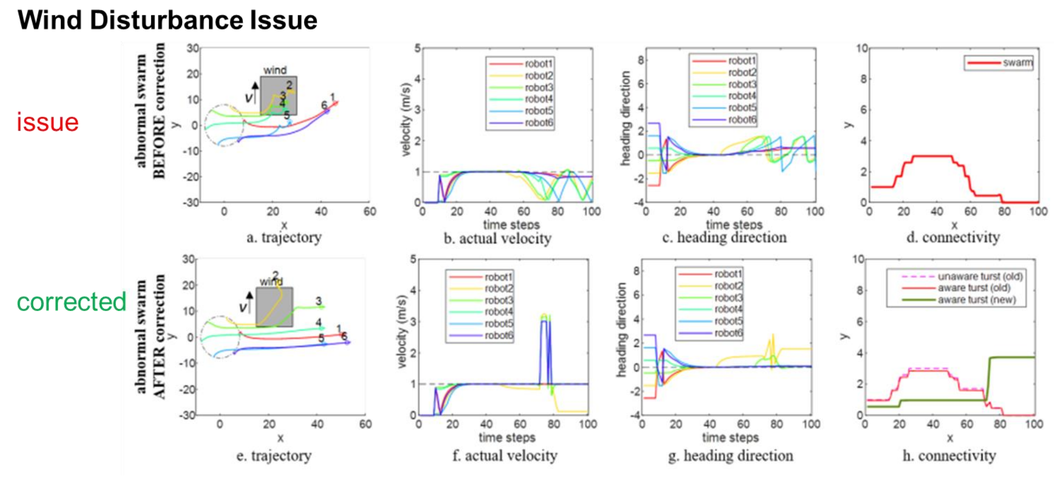
$$u_i[t+1] = \frac{1}{N_i+1}(u_i[t] + \sum_{j \in N_i} u_j[t]) \quad \Rightarrow \quad u_i[t+1] = w_i[t]u_i[t] + \sum_{j \in N_i} w_j[t]u_j[t]$$

Result

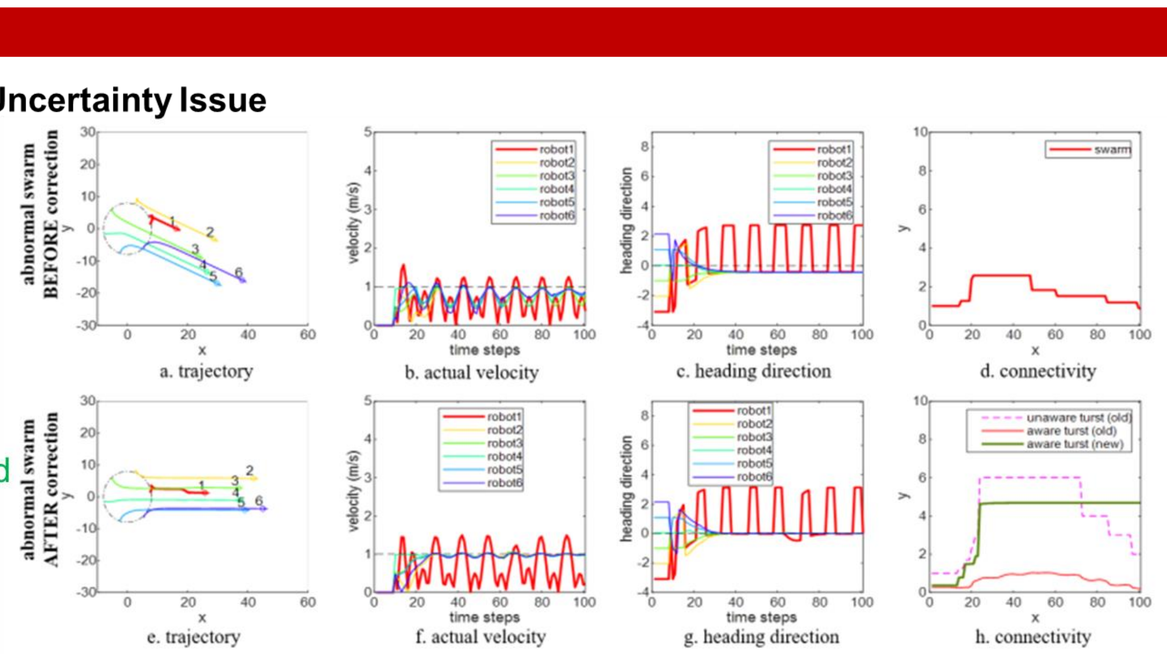
Degraded Motor Issue



Wind Disturbance Issue



System Uncertainty Issue



Based on real-world scenarios, three types of robot faults – degraded performance caused by motor wear, abnormal motion caused by system uncertainty and motion deviation caused by an external disturbance such as wind – were simulated to test the effectiveness of Trust-R.

Conclusion

Trust-R is effective in guiding swarm self-healing for effective human-swarm cooperation.