IMPLEMENTATION OF AN ULTRA-LOW COMPLEXITY VEX ROBOTIC SWARM

Peter H. Bauer, Yuzhe Liu, Duminda Dewasurendra
Department of Electrical Engineering
University of Notre Dame
Notre Dame, IN 46556

I. ABSTRACT

This paper introduces the results of implementing a medium size vehicle swarm of ultra-low complexity vehicles using the VEX robotic platform. The general goal of this swarm platform is autonomous navigation and sensing based on simple local interaction rules between agents which in turn gives rise to emergent behavior. One particular application focus is the detection of CBM contaminants in air, ground or water. The navigation algorithm of each (reactive) agent is extremely simple, and is based on previous work reported in [1][2]. (This simplicity allows to construct large swarms without encountering bottlenecks due to scalability limitations, complexity and cost explosions.) This previous work was solely based on simulations of the fundamental principles, which utilize potential fields generated by stationary and mobile radio beacons. (Attractive radio beacons are used to force agents to converge to areas of interest and control convergence towards nav-points or swarm leaders, while repellive beacons are used to perform obstacle avoidance and control swarm density.) It was shown that under ideal simulation conditions, these ultra low complexity agents were capable of solving a multitude of sensing and tracking tasks very efficiently. The method was found to be especially suitable for airborne and sea based platforms.

The goal of this paper is to show that this swarm paradigm actually works in practice, exhibiting high levels of robustness with respect to non-ideal and unmodeled effects. In particular, validation of this principle in the presence of phenomena such as large sampling times, non-circular antenna radiation patterns, RF noise, packet collisions, uncertain vehicle turn radius, agent speed variations and non-homogeneity of swarm agents in general were the main focus. Scalability of the swarm was yet another area of interest.

The results of this work shows that these unmodeled nonideal effects microscopically change the swarm agent behavior significantly, while macroscopically the global swarm behavior remains largely unchanged. The unmodeled effects create a certain randomness in the trajectory of each individual agents, making them extremely hard to predict. On the other hand, global swarm motion remains close to the desired and prescribed trajectory.

The resulting local agent and global swarm behavior will be documented by three videos that show the following swarm tasks:

(a) A simple two-agent leader-follower attractive and repellive scenario that microscopically shows some of the non-ideal effects on the swarm agent behavior.
(b) A 10 vehicle leader-follower swarm, where the leader follows a certain waypoint sequence and the followers ”swarm” around the leader.
(c) A multi-vehicle leader-follower swarm that detects simulated ground contaminations by searching over a certain area and marking ”contaminated spots” by the presence of a follower vehicle.
(d) Leaderless contaminant search within a convex hull of waypoints.

Even though the introduced swarm navigation principle was demonstrated and validated using a ground based platform, the same principle can be applied to UAV and sea based platforms. Typical applications range from oil spill clean up, mobile perimeter security (e.g. for water vessels), and mobile sea mines to airborne signature detection and tracking plumes in water and air.

Fig. 1 shows a snapshot of the swarming Vex robotic agents.

Fig. 1: Vex Robotic Swarm

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REFERENCES
