Mobile Autonomous Navy Teams for Information Surveillance and Search (MANTISS)

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Autonomous Inspection Swarms: Future Department of Defense combat and inspection teams may employ swarms of low-cost lightweight robotic vehicles to rapidly cover areas of interest and return information to field commanders. Such vehicles would be capable of searching for specific objects of interest (such as tanks, land mines, or injured humans), creating terrain maps of the topography noting the presence of potential obstacles to navigation, or building 3D maps of urban areas and scouting for potential threats (such as snipers) prior to the entry of warfighters. Such platforms could provide significant tactical advantage by supplying crucial information while minimizing risk to personnel. In order to achieve this vision, we have developed a methodology to autonomously operate these vehicles, with each vehicle performing sensor processing and path planning on board, while contributing to the overall mission of the team or swarm.

MANTISS Overview: The Mobile Autonomous Navy Teams for Information Search and Surveillance (MANTISS) Project has developed nature-inspired techniques for controlling teams or swarms of autonomous vehicles. These include area coverage and search using a Lennard-Jones potential field model, and an animal-inspired foraging algorithm. Information theory is used to provide metrics for the collective knowledge of the team. The goal then is at each time step to move the vehicles in such a way that information gain is maximized. All experimentation for this effort was conducted at the Naval Research Laboratory (NRL), Laboratory for Autonomous Systems Research (LASR), in the Prototyping High Bay, NRL's large indoor motion capture facility.

Autonomous Multiagent Multitarget Tracker: NRL researchers developed and demonstrated a motion planning strategy and controller for multiple mobile sensor platforms using visual sensors with a finite field-of-view for detecting and tracking of multiple mobile ground targets. The approach integrates information theory, Bayesian reasoning through the shared knowledge surface, and a physics-inspired emergent planner.

Visual sensors are used to collect position measurements of potential targets within the search domain. Measurements are assimilated using a Bayesian likelihood ratio tracker that recursively updates a probability density function over the possible target positions (see Fig. 3). Vehicles are routed using a novel, physics-inspired controller, in which vehicle motion depends on the target probability (temperature) at each location and the distance to nearby agents. Vehicles move along the negative gradient of the probability surface and interact with other agents. The gradient following behavior corresponds to locally maximizing the mutual information between the measurements and the target state. The performance of the approach was experimentally tested using visual measurements employing quadrotor sensor platforms equipped with downward-facing cameras. This capability could be used to control swarms of future Navy unmanned vehicles in a variety of Navy/Marine Corps missions.

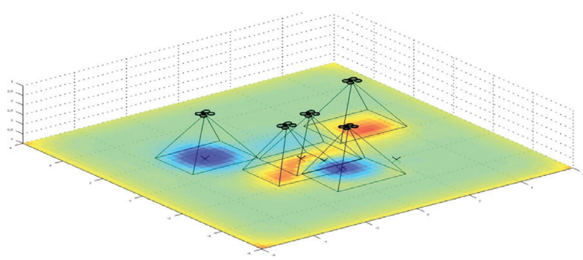

FIGURE 3
Bayesian likelihood ratio tracker.

Planner for Autonomous Risk-Sensitive Coverage (PARCov): A planner was developed to enable a team of unmanned aerial vehicles (UAVs) to efficiently conduct surveillance of risk-sensitive areas. The approach, termed PARCov (Planner for Autonomous Risk-sensitive Coverage), maximizes the area covered by the sensors mounted on each UAV while maintaining high sensor data quality and minimizing detection risk. PARCov uses a dynamic grid to keep track of the parts of the space that have been surveyed and the times that they were last surveyed. This information is then used to move the UAVs toward areas that have not been covered recently. A nonlinear optimization formulation is used to determine the altitude at which each UAV flies. The efficiency and scalability of PARCov was demonstrated in simulation using complex environments and an increasing number of UAVs to conduct risk-sensitive surveillance. It was then demonstrated using two AscTec Pelican quadrotors (see Fig. 4).

Terrain Classification for Small Autonomous Robots: Knowing the terrain is vital for small autonomous robots operating in unstructured outdoor environments. NRL researchers developed and demonstrated a technique using 3D laser point clouds combined with RGB camera images to classify terrain into four predefined classes: grass, sand, concrete, and metal. Figure 5 shows the results from an outdoor scene (LASR is shown in the background) using a small mobile ground robot.

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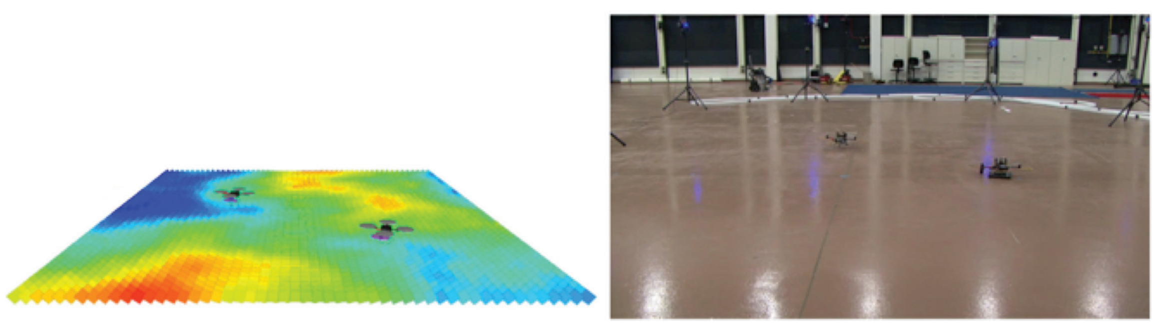

FIGURE 4
Planner for Autonomous Risk-Sensitive Coverage (PARCov).

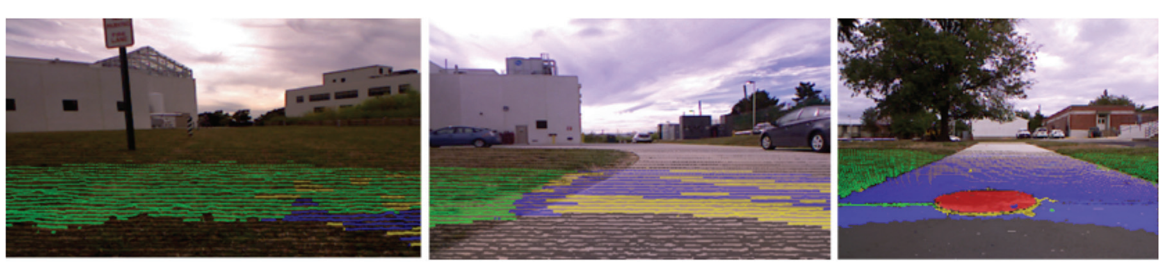

FIGURE 5
Terrain classification by a small mobile robot.

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