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CSCI 4314
Professor Peleg
March 21, 2019

Project Proposal: Search and Rescue Strategy

Team:

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The Problem:

Dogs are very good at tracking prey over long distances (and many miles) and they do so using a combination of airborne and depositional odorants.[1] Airborne odorants diffuse in the air and are often modeled according to Gaussian dispersion models and are easily affected by turbulence. Depositional odorants on the other hand are left behind on the ground as prey travels through a landscape and can be resuspended into the air and detected when disturbed (by wind or other animals). In tracking prey (like rabbits) or searching for humans (in the case of search and rescue missions), dogs rely on both of these odorants.[2]

Little is known about the navigational strategies that dogs use in these moving target scenarios, so the goal of this project is to *gain some insight into how dog's perform so well at this task*. In this project, we want *to find an optimal strategy for tracking a moving target* (prey or human to be rescued) where the only informational cues are airborne and depositional odorants. The strategies considered will be motivated by what is known about dog olfactory tracking (observed in experiment) and our models will be evaluated in simulations.

Significance:

The discovery of an optimal strategy for tracking a moving target though olfactory information would provide valuable insights for behavioral ecologists in understanding the search behavior of predators. This research could extend to explanations of the predator behavior under difficult conditions, such as increased wind and other disturbances. Any perceived behavior of different predators could also be explained by any discoveries of the strategy.

Any optimal search strategy we discover could also provide stronger techniques for search and rescue teams that require searching for a moving target (i.e. park rangers trying to find hikers that are actively moving around), or even the potential for implementation in robots seeking active targets through olfactory information.

Background and Related Work:

There has been a good amount of research into the optimal search strategies of animals for finding a hidden target (with an odor plume).[3] These strategies often involve two phases: a slow-moving phase where the agent sweeps a small area very intensely (and accurately) and a faster phase where the agent quickly moves to a new location.

There has also been a great amount of research into pursuit and evasion strategies in predator-prey interactions. There is for example extensive research into optimal attack trajectories of dragonflies or even Cheetah hunting strategies. Previous research has even looked at a pursuit predation technique called motion camouflage, which involves predators matching prey movement so that they appear to be non-moving (relative velocity of zero).[4,5]

In this paper, we are interested in considering a relatively unstudied predation behavior (tracking prey by odor), which is sometimes used for search and rescue purposes. This behavior is similar to finding a hidden target with the added twist that the target is moving.

Previous research has found that during olfactory tracking, dogs have three distinct phases: (1) an initial phase of track discovery characterized by fast movement in varied directions with short sniffing periods (in which they slow down), (2) a second, slower-moving phase to determine the direction of the track, (3) a third phase of tracing the track of the scent where the dog alternates between quick movement along the track and slow-moving sniffing periods (often near footprints) to stay on track.[6]

Previous research has found that an intermittent strategy where a relatively small amount of time is given to searching compared to relocating is very effective at finding a (non-moving) hidden target.[7] Similar intermittent strategies have also more recently been investigated for the moving prey problem. In a 2010 paper titled "Optimal intermittent search strategies: *smelling* the prey", researchers used an intermittent strategy and optimized the rate of switching between the two search states (slow and compact vs fast and large).[8] Other research has found an optimal strategy for initially finding the odor plume in turbulent conditions called Lévy-Taxis, which combines Lévy walks with a correlated random walk.[9] We will combine and attempt to implement a few of these techniques in our project in building a model agent to find a moving target. This paper will implement a chemotaxis agent, a random walk agent, and an intermittent strategy that involves components of RWs.

Plan:

We plan to work on the final paper throughout all the milestones, documenting findings for each model as we go.

Date	**Milestone**	**Details**	**Evaluation**
3/14 - 3/21	Project Proposal	After some initial background research and working through the starter code, we will have a proposed problem statement and weekly milestones planned out.	Turned in on time.
3/21 - 3/28	Refactor Code to Python	We have limited experience with MATLAB and our team feels more comfortable working in Python. In order to better understand starter code, we will refactor existing code in Python.	Same functionality as starter code (given to us by Professor Peleg) will be implemented in Python.
3/28 - 4/4	Random Walk vs Chemotaxis	We will first look at the case of a dog searching for a target using two strategies: (1) random walk (100% noise), (2) moving up the concentration gradient (no noise).	We should discover drawbacks of pure chemotaxis and pure Random Walk. We will also be able to better tune the wind speeds (turbulence) and decide on relative movement speeds for dogs vs target (if the

		These two strategies help give us a base for looking at best way to track a moving target given a few restraints (namely, slow accurate tracking by a dog and fast random movement).	dog/agent is much faster than the target does RW or chemotaxis work well?). The values of these variables will be decided based on empirical values.[2]
4/4 - 4/11	Implement Intermittent Search Strategy	Research suggests that dogs (and other animals) have a two-phase search strategy when tracking a trail: (1) slow more accurate movement (head down), (2) faster less accurate movement (head up)[6–8]	An intermittent search strategy (run and tumble style) is implemented and then compared to previous two models.
4/11 - 4/18	Composite Models	Previous models do not attempt to optimize the portion of the search where the dog had not yet found the odor plume, here we will implement a Lévy-taxis strategy to find the plume faster.[9]	New model will be implemented and compared to other models for various wind conditions.
4/18 - 4/25	Prepare for Presentatio n Day (April 25th)	Presentation should give background on the problem and show our novel contributions.	Have completed a presentation with a demo of our simulation and our intermediate findings.
4/25 - 5/2	Stretch Goasl/Wrap Up	If we have completed our previous milestones, see how well our models perform against adversary target trajectories (i.e. we know dogs do poorly when target has abrupt direction changes, high winds, etc) If not met all previous milestones, then use this week. *Stretch Goal*: We want to also look at comparing our model to real data (collected by Dr. Peleg's lab).	Have met all previous milestones. If time, we will have begun work on stretch goals.
5/2 - 5/9	Final Paper Due (on 5/9)	Complete our paper, finish any leftover analysis.	Turned in on time, meeting all criteria from rubric.

References

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