UAS SWARM SEARCH STRATEGIES

PROBLEM

In complex high-paced battlespaces, Defence seeks to use uninhabited aerial system (UAS) swarms to project force deep in hostile territories. In these environments, we do not have the luxury of knowing where or how many enemies are present, making it nearly impossible to achieve most mission objectives.

As our targets exist in the real world, we can take cues from man-made structures, terrain data and road networks to predict likely patterns of behaviours and therefore bias our belief space to those areas which are likely to contain targets. This is a core problem of active perception; we need to select behaviours which increase the flow of useful information to our swarm to perform adequate mission planning.

Traditional search would mean that there is either no prior information about target likelihood, or a prior in the form of a probability density function, and detection likelihood can be represented as a sensor model roughly in the form of probability of (true) detection given a target, probability of (false) detection given no target. In this case, active perception means that we would have a more complicated detection likelihood that involves sensor viewpoint and probability of classification, and target priors are dependent on semantic features (the roads/terrain). Those two properties imply that robots must reason about future viewpoints, cooperatively, in order to satisfy an optimisation objective such as minimising mission time or maximising performance given fixed mission time - online and in real time.

In this project, we are seeking Universities to develop active perception algorithms using visual-band sensors to perform a task-based search. This development will significantly enhance Defence's capability to effectively operate autonomous UAS swarms in unknown environments.

NEED/RELEVANCE TO DEFENCE

Currently, to perform a task using a swarm of UAS, we require extensive detail and information about the environment we operate within to perform task planning. However, these approaches are rigid, and inflexible to changing strategies when the model of the environment differs to what is observed. Most approaches to solve these problems are heuristic-based and do not scale well. This significantly limits the effectiveness and defensive capability of our autonomous UAS.

RESEARCH QUESTION

Given a contested semi-urban environment and an unknown number of hostiles, what is a computationally efficient algorithm to find an optimal set of solutions (i.e., paths) for a team of robots?

EXPECTED OUTCOMES

We seek for the partners to demonstrate a simulation of target searching behaviour with at least 2 UAS in a low-fidelity 3D environment. Given a task specification, for example "find the safest passage to hostage", the time-minimal set of paths is to be found. The algorithm needs to be decentralised across the swarm while assuming full-bandwidth communication. The assessment over the solutions must provide a quantitative reasoning for post-mission decision making.

METHODOLOGY/ APPROACH

We seek to leverage the use of recent advancements in active perception, in particular, decentralised Monte-Carlo tree search. We request that only visual-band sensors are used, and the computational complexity of search algorithms are considered with regards to feasible on-board processing of a UAS.