Search Problems With Swarms

The main research area of the project is to study swarms. Swarms are large groups of fairly primitive but cost effective entities (robots, agents) that can be deployed to perform an exploration or a monitoring task.

Swarms can be deployed to perform a task in hard to reach or hostile environments, and there are many algorithms that exist to deal with a variety of control problems in these robot swarms.

**Network Search and discovery:** Searching a network to map its topology or searching for a significant point.

**Rendezvous/Gathering:** Agents work together to meet up at some point in the network, or perform some synchronised gathering task.

**Network Patrolling:** Agents work together to secure an area or boundary of the network either through regular patrols or surveillance monitoring.

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**Problem:**

The Location Discovery Problem is for each agent to determine the initial position of every other agent and eventually stop at its initial position, or proceed to another task, in a fully synchronised manner.

**Model:**

- There are \( n \) uniform anonymous agents located on a circle with unit circumference.
- The agents are located at positions unknown to other agents.
- The agents perform actions in synchronised rounds.
- At the start of each round an agent chooses to move either clockwise or anticlockwise.
- Agents are not allowed to overpass and upon a collision they instantly start moving with the same speed in the opposite direction.
- Agents cannot leave marks on the ring or exchange messages.
- Agents have zero vision but on the conclusion of each round each agent has access to (some, not necessarily all) information regarding its trajectory during this round.
- This information can be processed and stored by the agent for further analysis.

**Result:**

Our main result is a fully distributed randomised algorithm, solving the Location Discovery Problem with high probability in \( O(n \log^2 n) \) rounds.

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**Network Analysis**

Network analysis is a useful task for a wide variety of application domains. For example social, financial, biological and transport networks.

This analysis is done on the network structure to reveal useful insight into relationships, network entities and clusters.

There are many approaches to network analysis, here are just a few:

**PageRank:**

- The popular method used by Google to help rank web pages in its search engine.
- The algorithm gives a value to each vertex in a network that denotes its relative importance within the network.
- This value is defined recursively and depends on the number of edges pointing into a vertex and the value of the vertex that that edge is coming from.

**Betweenness Centrality:**

- A useful strategy when dealing with large complex networks.
- Betweenness Centrality locates vertices that act as hubs in the network by counting the number of shortest paths from all vertices to all others in the network that pass through each vertex.
- Essentially this algorithm helps find bottle necks within a network.

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