**Project Title:**

snHm Drone Swarm project

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**Github link:** <https://github.com/MephilesTD6/snHm>

**Project Description:**

1. **Introduction to Drone Swarms**

An unmanned aerial vehicle (UAV) or more commonly known as a drone is a flying robot that can be remotely controlled or fly autonomously using software-controlled flight plans in its embedded systems, which work in conjunction with onboard sensors and a Global Positioning System (GPS). Drones generally come with four double-bladed propellers, which are spun by motors to generate lift, attached to four branches which are connected to the main body in the centre.

A drone swarm consists of multiple drones deployed together to achieve a common objective, which will be elaborated on in the next section. These drones operate collaboratively in a system by constantly communicating and coordinating with each other to perform tasks efficiently. The idea of a drone swarm originated from the natural formations of animals that work together in specific formations, such as an ant colony or a flock of migrating birds, which distribute intelligence to enhance their chance of surviving as a species.

1. **Applications of Drone Swarm Technology**

Agriculture is one of the areas which can benefit from the application of drone swarm technology. Drone swarm technology can be used to plant seeds, identify breakouts and diseases in plants, and deploy treatments and fertilizers to plants. It also helps to monitor the growth of crops and plants, or to research the dispersion of pests in a farm to determine potential breeding areas for pests which harm the crop.

Another crucial application of drone swarm technology is in emergency response and management. Responders could use drone swarms to find missing persons and deliver emergency care and supplies during natural disasters such as flash floods and storms. Drone swarms could also help firefighters track and control the spread of wildfires and collect information about damages, access points, and more.

The most common application of drone swarm technology today is in entertainment. Drone swarms can be used as a substitute for fireworks which can release debris, air pollutants and cause irritation to plants and animals, hence providing a greener alternative.

1. **Algorithms in Drone Swarming**

The first algorithm which can be applied was proposed by Olfati-Saber which is based on potential fields and graph theory. It is based on the construction of a collective potential that penalizes the deviation of the agents from a lattice shape. At the equilibrium, in the absence of obstacles, the agents occupy positions at a constant distance from their neighbours and translate with constant velocity.

The second algorithm that can be implemented in drone swarming is an adaptation of the recent Vasarhelyi’s algorithm which are defined by the repulsion to avoid inter-agent collisions, velocity alignment to steer the agents to an average direction, and self-propulsion to match a preferred speed value.

The last algorithm is the Boids algorithm which was proposed by Craig Reynolds. [Boids](https://en.wikipedia.org/wiki/Boids) is an artificial life program that produces startlingly realistic simulations of the flocking behaviour of birds. Each "boid" follows a very simple set of rules which are separation, alignment and cohesion. The first rule, separation tells the boids to move away from other boids that are too close to each other. The second rule, alignment tells the boids to match the velocities of their neighbours and the final rule, cohesion tells the boids to move towards the center of mass of their neighbours.

1. **Data structures in drone swarm tech**

Data structures are crucial for drones to store, access, and modify information efficiently.

a. Graphs

Graphs are a key data structure in drone swarms for navigation and communication.

Graph-Based Navigation: In pathfinding, the environment is often represented as a graph, with nodes corresponding to points in space and edges representing possible paths. Algorithms like A\* traverse these graphs to find optimal paths.

Communication Graphs: Drones communicate with one another using a network graph. Each node represents a drone, and edges represent communication links. This helps maintain the swarm’s integrity and allows the group to share information effectively.

b. Spatial Partitioning Structures

To manage spatial data, drones often use spatial partitioning data structures, which help break down large areas into manageable segments for exploration, mapping, and collision avoidance.

Quadtrees: These are hierarchical structures that divide a 2D space into quadrants, recursively partitioning the space for faster collision detection and navigation.

Octrees: For 3D environments, octrees extend this concept by partitioning space into eight sub-volumes. Drones can use these structures to efficiently detect nearby obstacles and other drones in 3D space.

c. Distributed Hash Tables (DHT)

DHTs can be used for decentralized data storage and retrieval, ensuring that each drone can store and retrieve information without needing a central server.

In a swarm, DHTs allow drones to share information like maps, sensor readings, or locations of interest in a distributed way, preventing any single point of failure.

d. Message Queues and Buffers

Efficient communication requires message queues, where each drone buffers incoming messages and processes them in a specific order. These queues ensure that important messages are not lost and that data flows smoothly across the swarm.

1. **Combining Algorithms and Data Structures**

Algorithms and data structures in drone swarms must work together efficiently to ensure robust, scalable, and reliable performance.

Data Sharing and Consensus: Drones use data structures like graphs and hash tables to store local data and algorithms like consensus protocols to synchronize data across the swarm.

Task Allocation: Optimization algorithms combined with priority queues allow the swarm to assign tasks dynamically based on resource availability, reducing the need for central control.

Navigation and Obstacle Avoidance: Pathfinding algorithms use graph structures to ensure smooth navigation while keeping track of drone positions and avoiding collisions.

1. **Conclusion**

Drone swarms are highly reliant on sophisticated algorithms and well-structured data management systems. Algorithms enable drones to collaborate, navigate, and optimize their tasks, while data structures manage the vast amounts of information needed to make these algorithms function efficiently.

References

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