Mission Coordination — UAV Delivery System

Coordination, Planning, Trajectory, Vision

1 Exercise 1 — Architecture

1.1 Hierarchical UAV Architecture

Perception Layer

- Payload measurement
- Pressure measurement
- Shape database
- Learning module

Decision Layer

- Task planning
- Path planning
- Exploration strategy

Control Layer

- Inner control loop
- Outer control loop
- Grasping
- ESC (Electronic Speed Controller)
- Propeller

1.2 Missing Tasks

- Inter-UAV communication
- Collision avoidance
- Energy management
- Localization (GPS / SLAM)
- Fault detection and recovery

1.3 Task Planning — Formal Definition

Notation:

$$\text{At}(Object/Drone, x, y, z)$$

Grasp(Object, x, y, z)

- Preconditions:
  - $\text{At}(Drone, x, y, z)$
  - $\text{At}(Object, x, y, z)$
  - Object weight $\leq$ drone capacity
- Consequences:
  - Object attached to drone

Move(Drone, From, To)

- Preconditions:
  - $\text{At}(Drone, From_x, From_y, From_z)$
  - Collision-free path
- Consequences:
  - $\text{At}(Drone, To_x, To_y, From_z)$

Give(Object, x, y, z)

- Preconditions:
  - Drone carrying object
  - $\text{At}(Drone, x, y, z)$
- Consequences:
  - $\text{At}(Object, x, y, z)$
  - Drone no longer carries object

1.4 Cooperative Task

Cooperative_Grasp(Object)

- Multiple drones at same position
- Combined lifting capacity sufficient
- Load shared between drones

2 Exercise 2 (A* Search)

2.1 8-Connected Grid Advantage

- Shorter paths
- More natural motion
- Better obstacle avoidance

2.2 Closed List vs Path

- Closed list: explored nodes
- Final path: optimal solution from goal to start

2.3 Heuristic Purpose

- Guides search toward goal
- Reduces computation

2.4 Heuristic Function

Diagonal motion allowed $\Rightarrow$ Euclidean distance:

$$h(n) = \sqrt{(x_g - x_n)^2 + (y_g - y_n)^2}$$

2.5 A* Cost Function

$$f(n) = g(n) + h(n)$$

Where:

- $g(n)$: cost from start (each move = 2)
- $h(n)$: heuristic to goal

3 Exercise 3 — Vision Application

3.1 SLAM Definition

SLAM = Simultaneous Localization And Mapping

Sensors

- Camera
- LiDAR
- IMU

3.2 SLAM Problematics

- Drift $\rightarrow$ Loop closure
- Poor lighting $\rightarrow$ Sensor fusion
- Feature ambiguity $\rightarrow$ Artificial markers

3.3 Multi-UAV Localization

- Cooperative / Distributed SLAM
- Shared maps improve accuracy

3.4 Robotic Tags (ArUco / AprilTag)

- Precise relative localization
- Package identification
- Grasp and delivery validation