Indian Institute of Engineering Science & Technology, Shibpur
Department of Computer Science & Technology
8th Semester Artificial Intelligence Laboratory 2025
CS 4271

1. A disaster has struck a **futuristic smart city**, and your task is to develop an **AI-powered drone navigation system** to **rescue stranded survivors**. The drone must **autonomously navigate through the city**, avoiding obstacles like collapsed buildings and fire zones while optimizing for the fastest route (equivalent to minimum energy consumption).

   Your objective is to implement the *A Search Algorithm** to guide the drone from its **starting position (S)** to **rescue multiple survivors (G1, G2, ... , Gn) (intermediate states) and return to base (B) (treated as goal state)** while minimizing energy consumption and ensuring safe traversal.

Grid Representation of the City (State Space Representation of the City):

The smart city is represented as a **3D grid** where each $(\boldsymbol{x}, \boldsymbol{y}, \boldsymbol{z})$ coordinate defined as: (x, y) in the 2D coordinate and z values is the depth of flying at different levels. Each of the depth 'z' is represented by different notations as:

- **Roads & Open Spaces** (`0`) → The drone can fly here.
- **Buildings/Collapsed Structures** (`1`) → The drone **cannot** pass through.
- **Fire Zones** (`F`) → High-risk zones. Passing through **incurs an extra cost**.
- **Survivor Locations** ($G_1, G_2, \ldots, G_n$) → The drone must **visit and rescue them**.
- **Recharging Stations** (`R`) → The drone can **stop and recharge energy** if needed.
- **Base Station** (`B`) → The drone must **return here after completing the mission**.
- **Drone's Start Position** (`S`) → Where the drone begins.

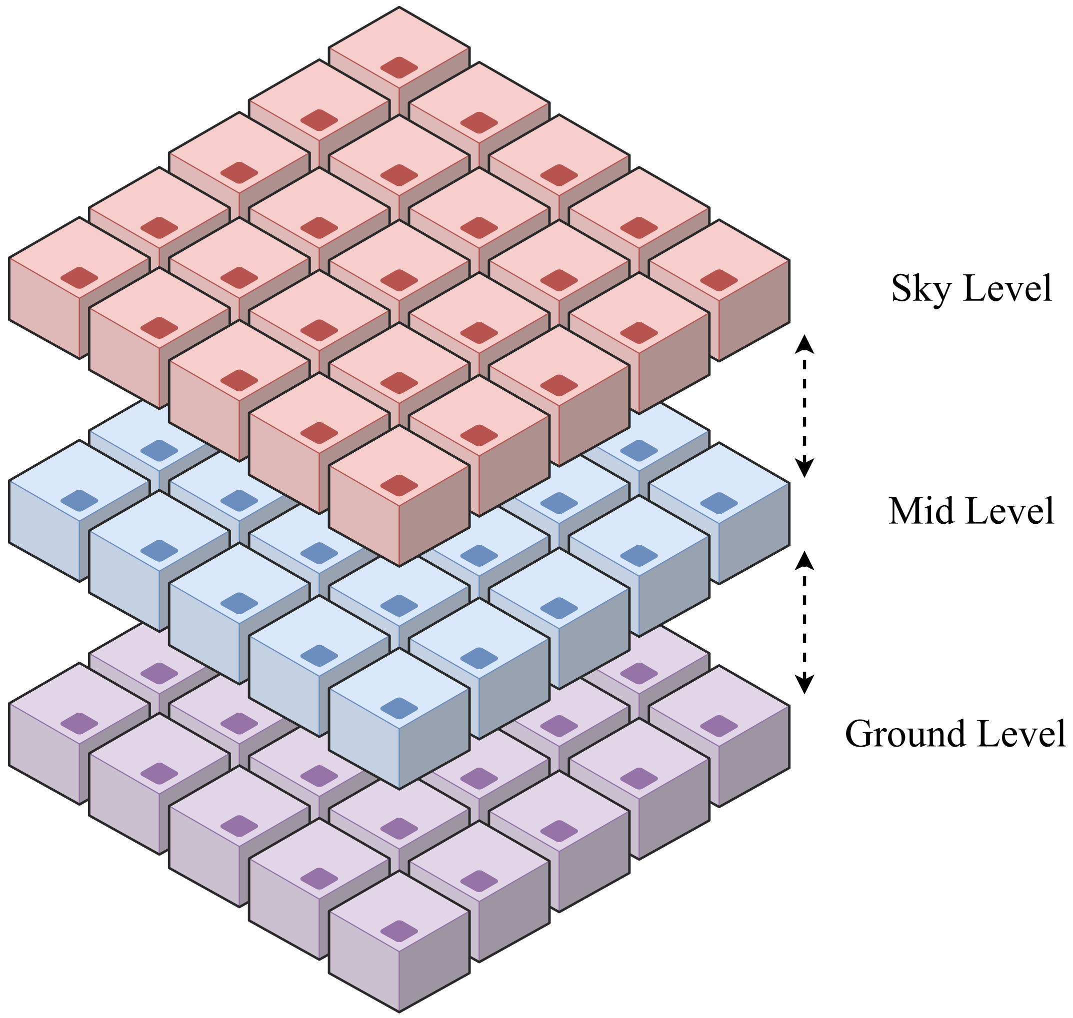
Drone Movement and Cost Considerations:

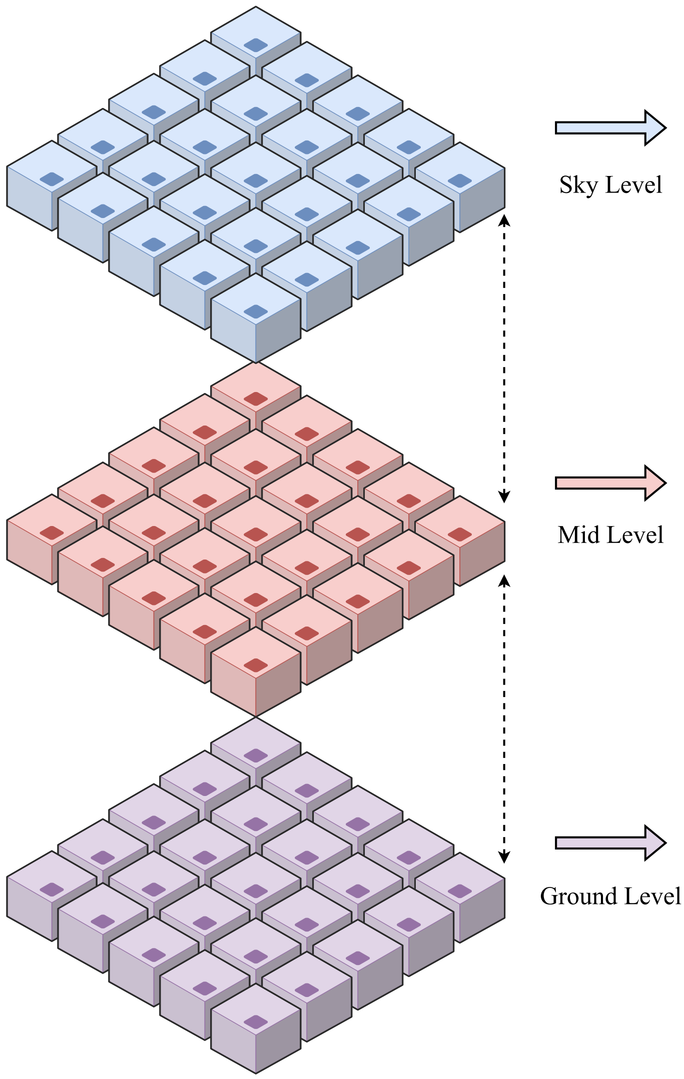
a) **The drone moves in 3D space**:
   - **Up** `(x, y, z+1)`, **Down** `(x, y, z-1)`,
   - **North** `(x-1, y, z)`, **South** `(x+1, y, z)`,
   - **East** `(x, y+1, z)`, **West** `(x, y-1, z)`.
   - **Diagonal movements** (like flying at an angle) **are not allowed** for simplicity.

b) **Energy Consumption Factor:**
   - Moving through **clear space (0)** costs **1 energy unit**.
   - Moving through **fire zones (F)** costs **3 energy units** due to turbulence.
   - Moving **upwards (z+1) costs extra 2 energy units**, while descending `(z-1)` costs **1 energy unit**.

c) **Objective:**
   - The drone **must rescue all survivors** before returning to base `(B)`.
   - The **optimal path minimizes total energy consumption**.
   - If needed, the drone can **recharge at (R)**, but stopping at a station adds a **fixed time penalty**.

Example Grid Input (5×5×3):


Sky Level
Mid Level
Ground Level



1	0	0	0	0
0	F	0	1	0
0	0	1	0	F
0	0	0	0	0
0	1	0	0	1

0	0	1	0	0
0	1	1	0	0
F	0	0	0	1
0	1	1	1	0
0	0	0	0	0

S	0	1	0	0
0	F	1	1	G_1
F	0	0	0	F
R	1	1	1	0
B	0	1	0	G_2

Implementation Guidelines:

a) *Use A search algorithm** to compute the most energy-efficient path.
b) **Priority Queue (Min-Heap)** should be used to store nodes with the lowest `f(n) = g(n) + h(n)`.
c) **Heuristic (h(n))**: Use a **3D Euclidean distance** to estimate cost to the goal:

$$h(n) = \sqrt{\left(x_{current} - x_{goal}\right)^2 + \left(y_{current} - y_{goal}\right)^2 + \left(z_{current} - z_{goal}\right)^2}$$

d) **Account for terrain cost penalties** (e.g., fire zones, vertical movement, etc.).
e) **Recharging Logic**: If energy is too low to reach the next goal, navigate to the nearest `(R)` station.
f) **Ensure the algorithm supports multi-goal search**, as the drone must **visit multiple survivors** before returning.
g) **Handle Edge Cases**:
 - No valid path exists to all survivors.
 - Energy depletion before reaching a recharge station.
 - The base `(B)` is unreachable due to obstacles.