Technical Explanation

This algorithm provides a stable and efficient frontier selection strategy for robotic exploration of unknown environments, with a particular focus on avoiding oscillations during target selection. Below is a concise technical description:

Core Concepts

- **Manhattan and Euclidean distances**: Used to evaluate the distance between the robot’s current position and candidate targets.
- **Free-or-unknown cell check**: Determines whether a grid cell is traversable (either known free or uncertain), ensuring safe navigation.
- **Local A* search**: Performs a constrained A* search within a local neighborhood to find a short feasible path while limiting computational cost.

Key Components

1. **Frontier Enhancement**: The final goal cell (`goal_cell`) is explicitly added to the frontier candidate list if it is reachable and adjacent to known free space. This ensures goal-directed progress even when traditional frontiers are scarce.

2. **Scoring System**: Each candidate target is scored based on multiple criteria:
   - Alignment between the robot’s heading and the direction to the target
   - Progress toward the global goal (measured via Manhattan distance reduction)
   - Proximity to the robot (closer targets are slightly favored)
   - A switching penalty to discourage frequent target changes
   - A large bonus for the global goal cell to prioritize it strongly

3. **Hysteresis-Based Oscillation Prevention**: To avoid chattering between nearby targets, the algorithm retains the previous target if the new candidate is very close (<2 cells) and lies in an opposing direction (angle >120°). A counter tracks consecutive selections of the same target to reinforce stability.

4. **Fallback Behavior**: If no valid frontier is available, the robot attempts to move 1–3 steps toward the global goal along its current heading. If that fails, it defaults to staying in place—ensuring a safe, valid action under all conditions.