16-350
Planning Techniques for Robotics

Case Study:
Planning for
Coverage, Mapping and Surveyal

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Definitions

- Coverage
  - Traversal of a known map with a goal of fully examining it using on-board sensors (e.g., museum security, car painting, lawn mowing, etc.)
- Mapping
  - Traversal of an unknown map with a goal of fully building it using on-board sensors (e.g., search for people in an unknown building)
- Surveyal
  - Visiting a set of waypoints of interest with a goal of surveying them using on-board sensors (e.g., surveillance)

Examples of Coverage

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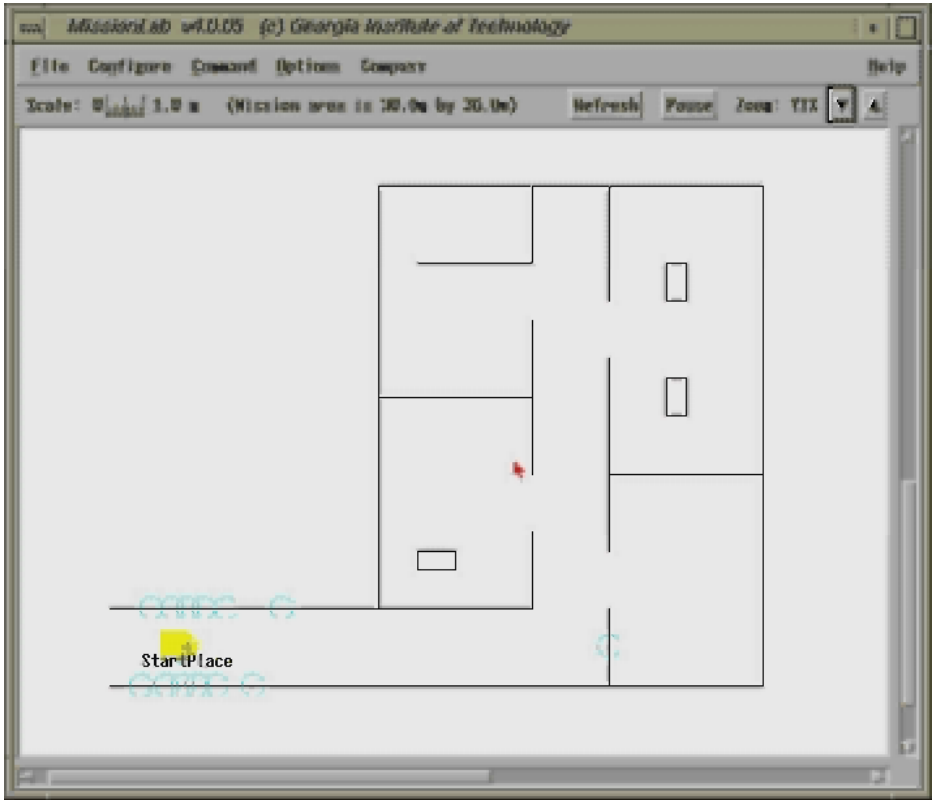

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What would be a good strategy for traversal of a known obstacle-free region?

Random traversal (e.g., Roomba for floor vacuuming) is always an option. Anything else?

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Lawn-mowing pattern

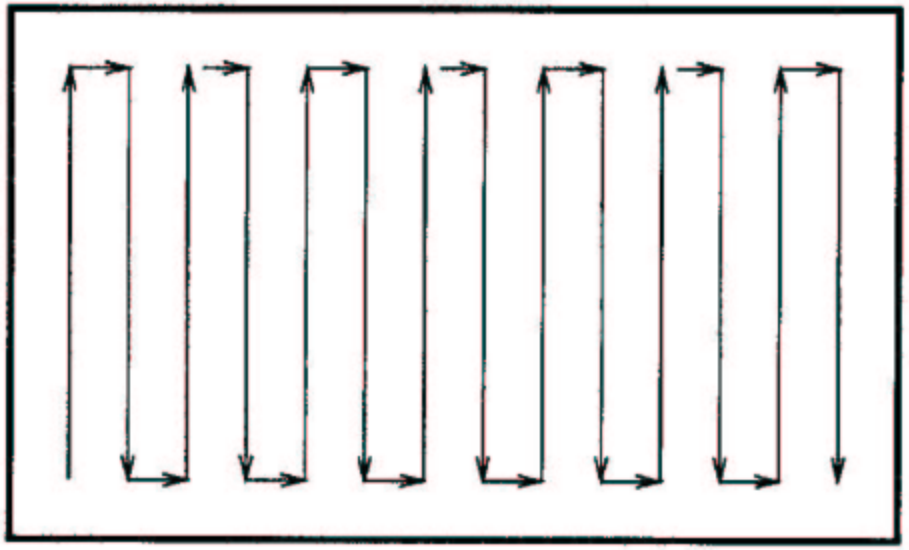

image borrowed from H. Choset, '01

Examples of Coverage

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Doesn't work well for covering regions with obstacles

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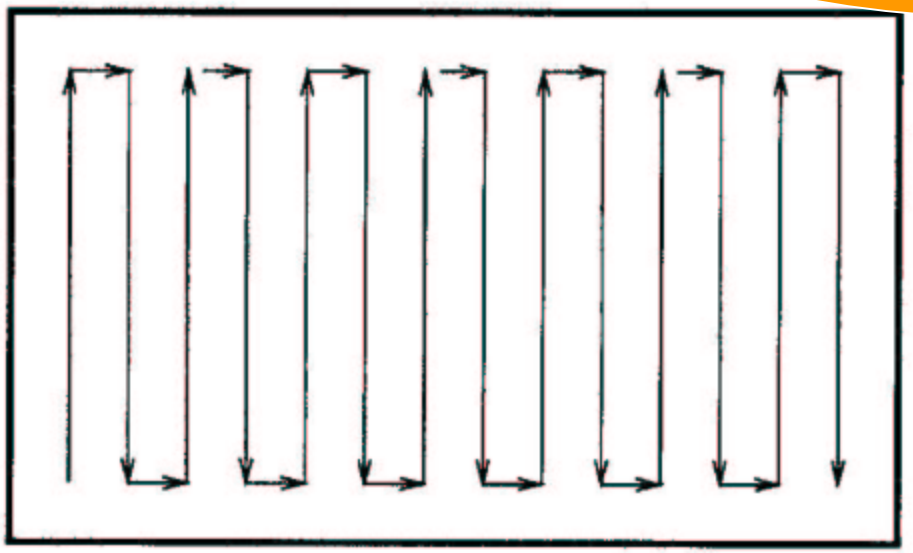

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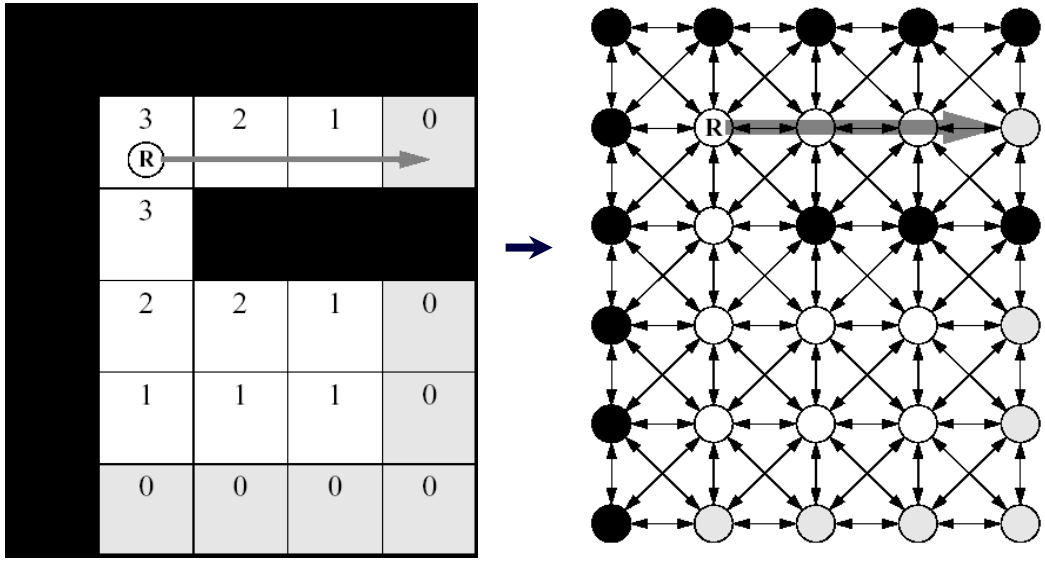
Frontier-based Coverage

- Always move the robot to the nearest cell that hasn't been "covered" (observed/visited) yet (one of the frontier cells)

How do you find a path to the nearest "unobserved" cell?



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Remember graph transformation for Multi-goal A! (previous lecture)*

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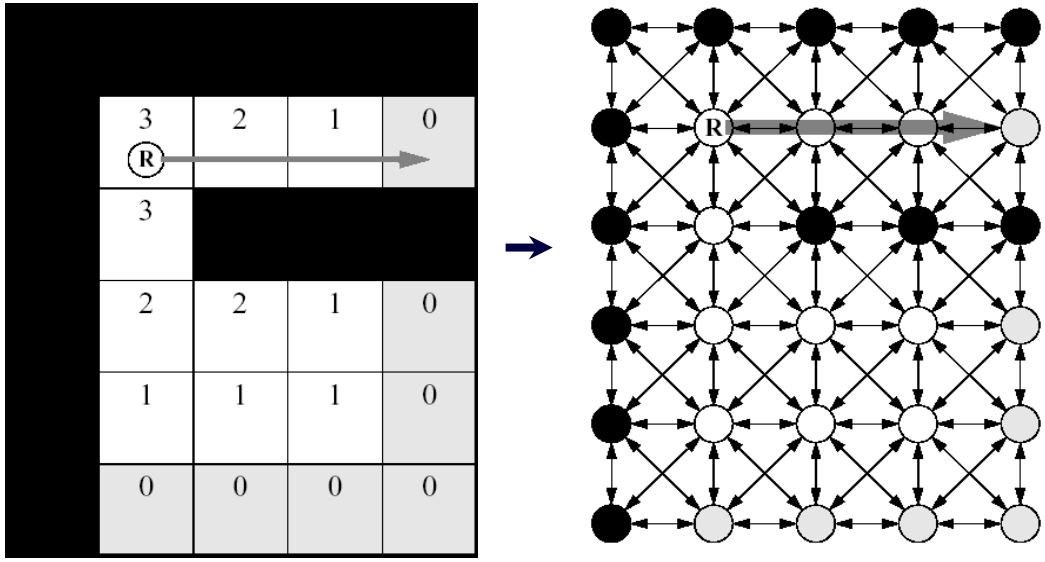

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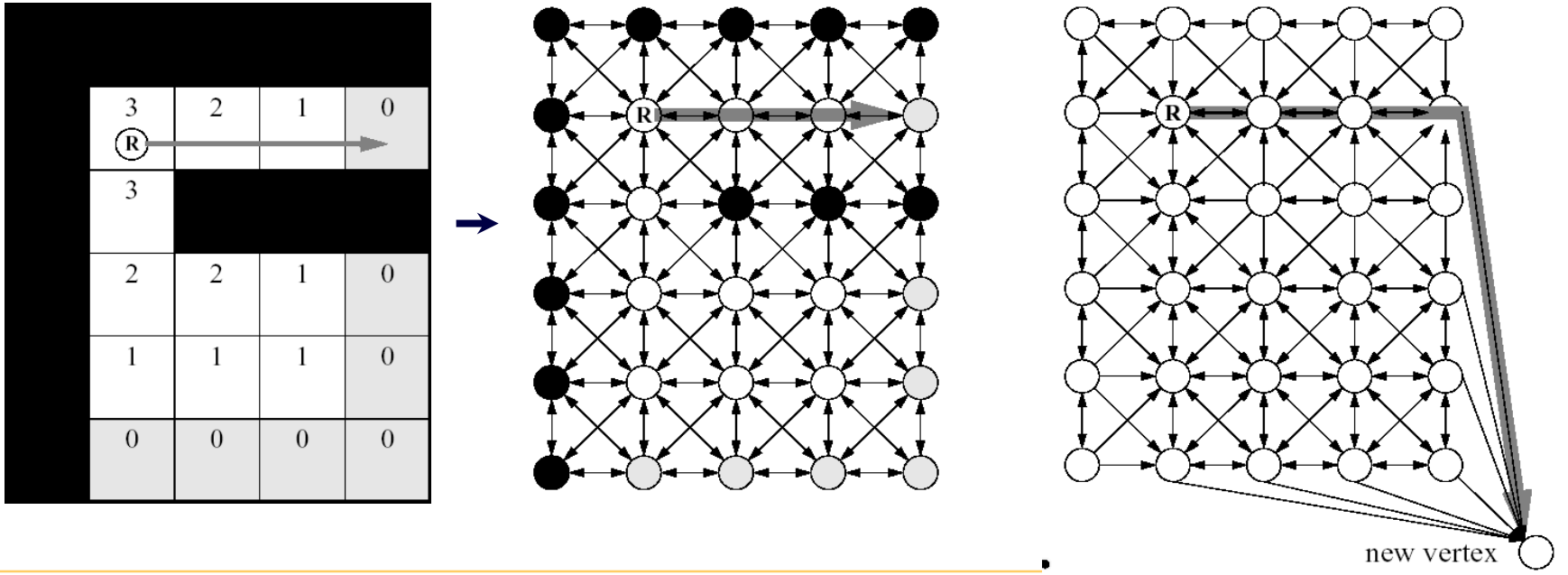


Examples of Mapping

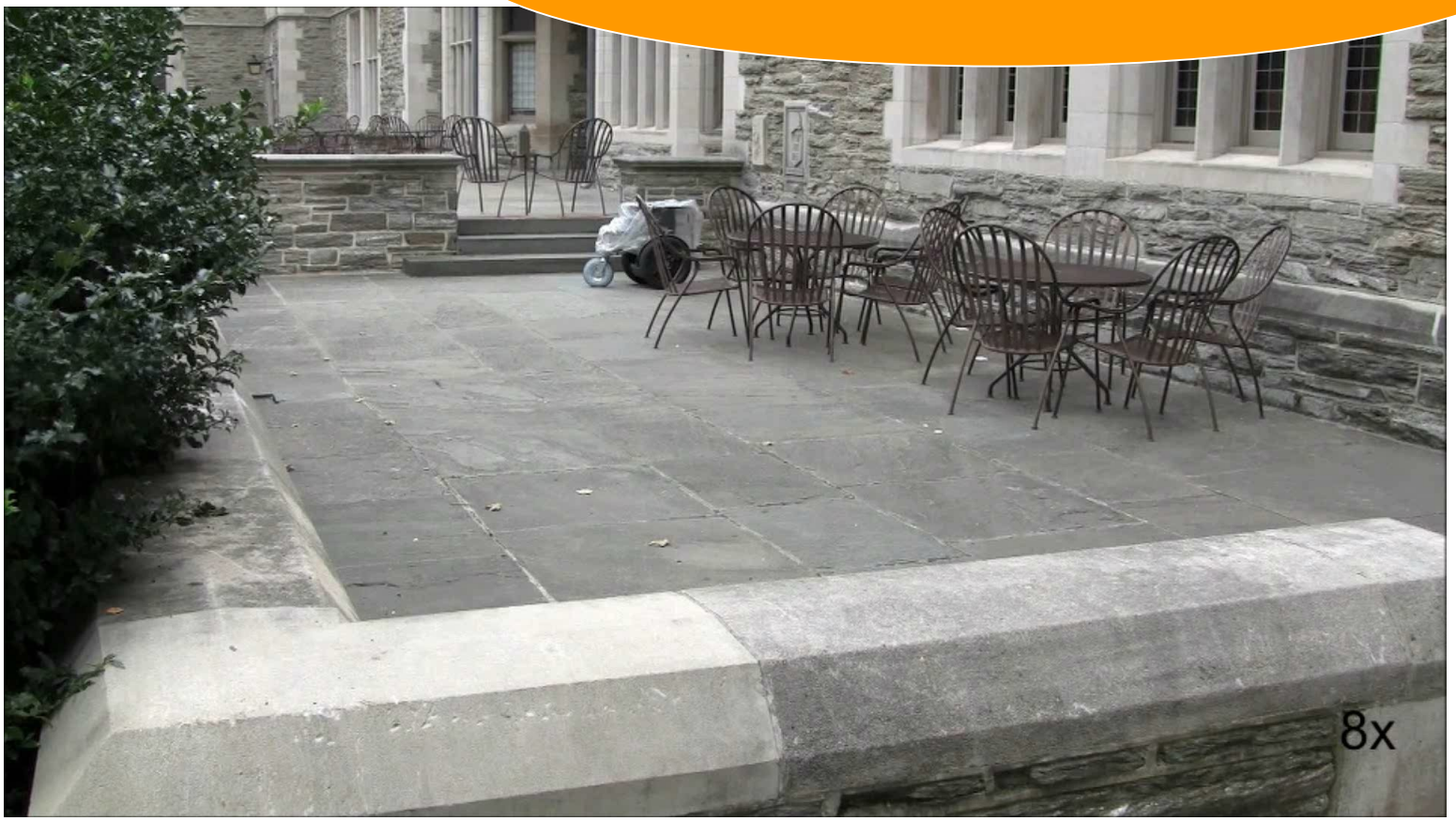
- Mapping
  - Traversal of an unknown map with a goal of fully building it using on-board sensors (e.g., search for people in an unknown building)

Examples of Mapping

Any ideas on planning for mapping?

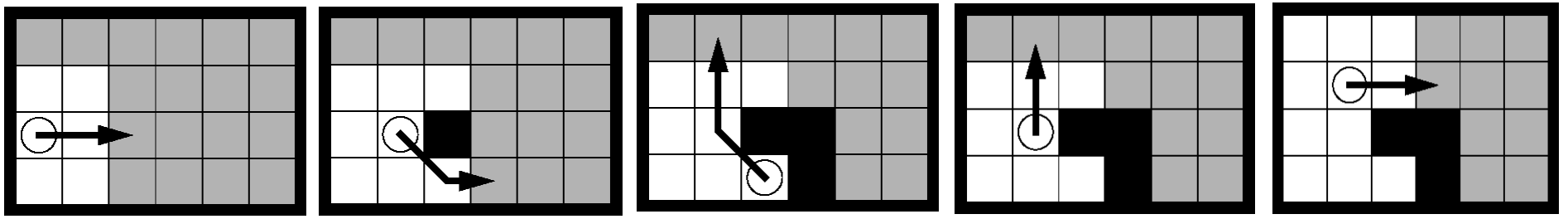
- Mapping
  - Traversal of an unknown ma… it using on-board sensors (e.g…

Same process as for coverage except that map gets discovered on the way



Greedy Mapping (Frontier-based method)

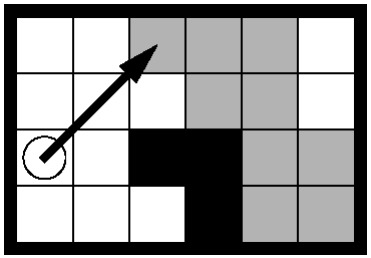
- Always move the robot on a shortest path to the closest unobserved (or unvisited) cell.



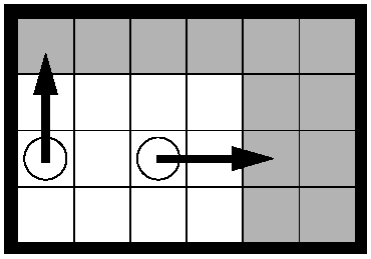
  - *It always achieves a gain in information.*
  - *Thus, it maps the terrain.*

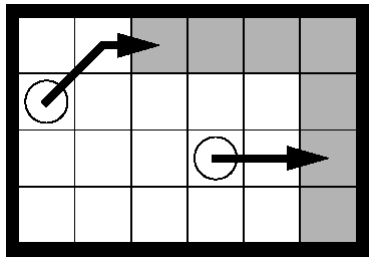
Greedy Mapping (Frontier-based method)

- Always move the robot on a shortest path to the closest unobserved (or unvisited) cell.
  - Utilizes prior map knowledge, if available



  - *Can be used for mapping with multiple robots*

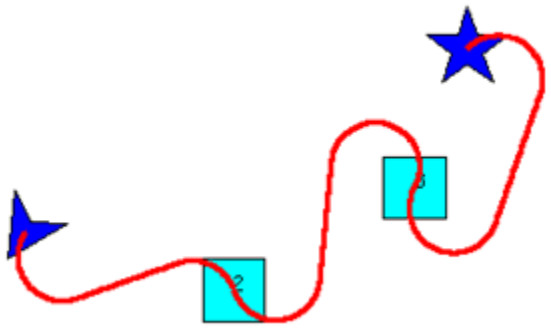




  - *Has a reasonably small mapping time*

Examples of Surveyal

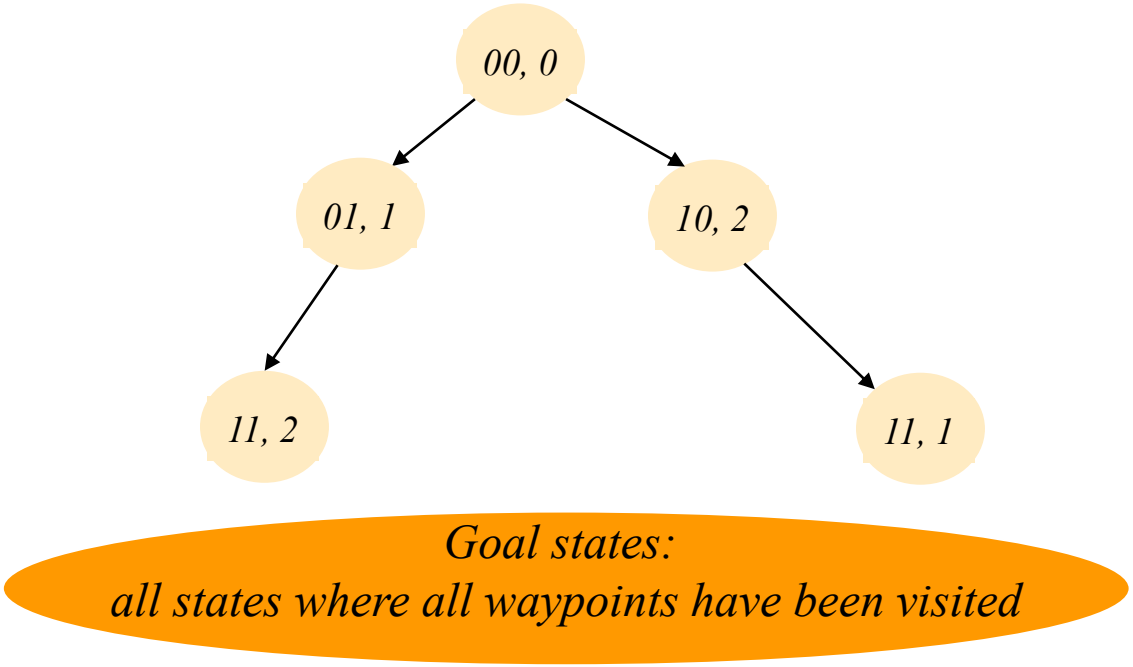
- Surveyal
  - Visiting a set of waypoints of interest with a goal of surveying them using on-board sensors (e.g., surveillance)



computing a least-cost path that visits all waypoints of interest (in any order) while being feasible (e.g., satisfies minimum turning radius, is collision-free, etc.)

Planning for Surveyal as Graph Search

- Search graph G = {V, E}
  - Each node $v \in V$ is defined as $\{ \alpha , \Omega \}$
  - α is a vector of M bits where a *0 bit indicates the corresponding waypoint is unvisited and 1 bit indicates it is visited.*
  - Ω encodes the waypoint where the robot is currently at and the orientation of the robot (if the robot is NOT omnidirectional).



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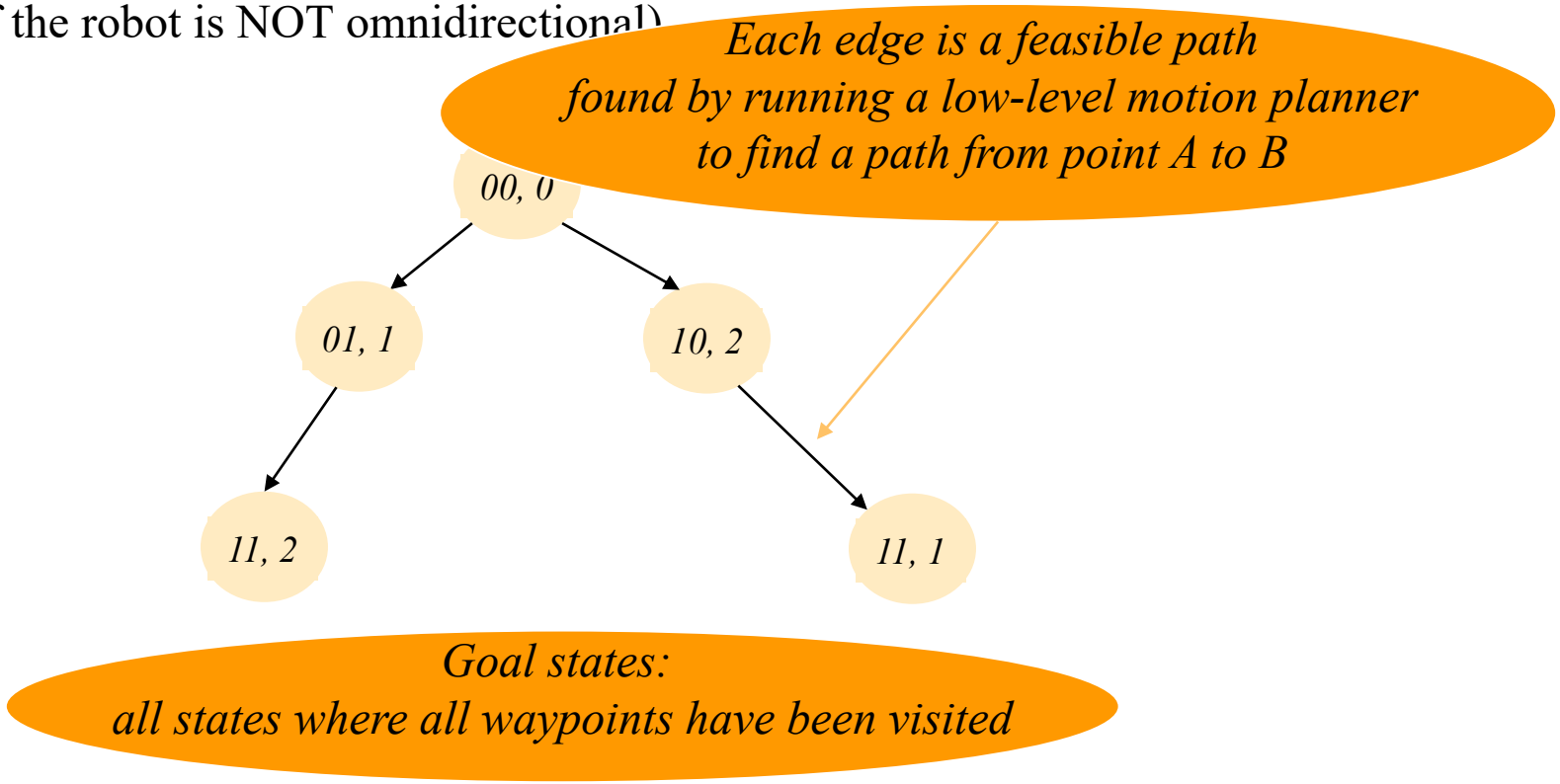

Summary

- Planning for coverage and mapping is often based on finding a path to the nearest unobserved cell (running Multi-goal A*)

- Planning for Surveyal is often decomposed into several layers of planning
  - low-level planning for finding feasible transitions between waypoints of interest
  - high-level planning to compute the order of visiting waypoints of interest