

16-782

Planning & Decision-making in Robotics

***Case Study:
Planning for
Coverage, Mapping and Surveyal***

Maxim Likhachev

Robotics Institute

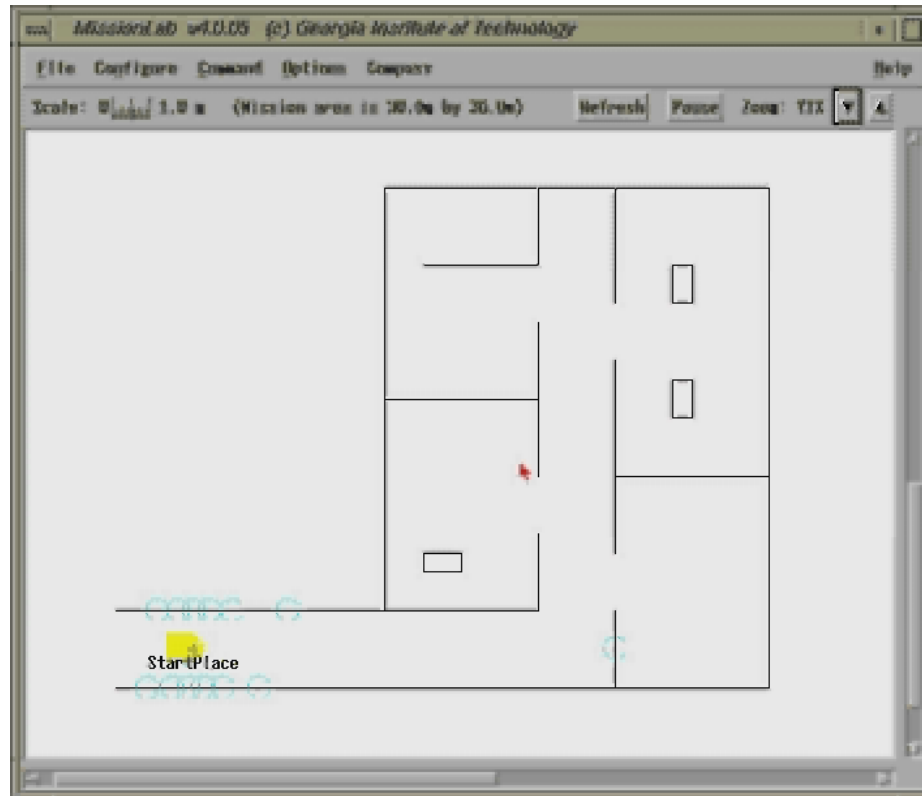
Carnegie Mellon University

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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*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?*

Example of Coverage

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Lawn-mowing pattern

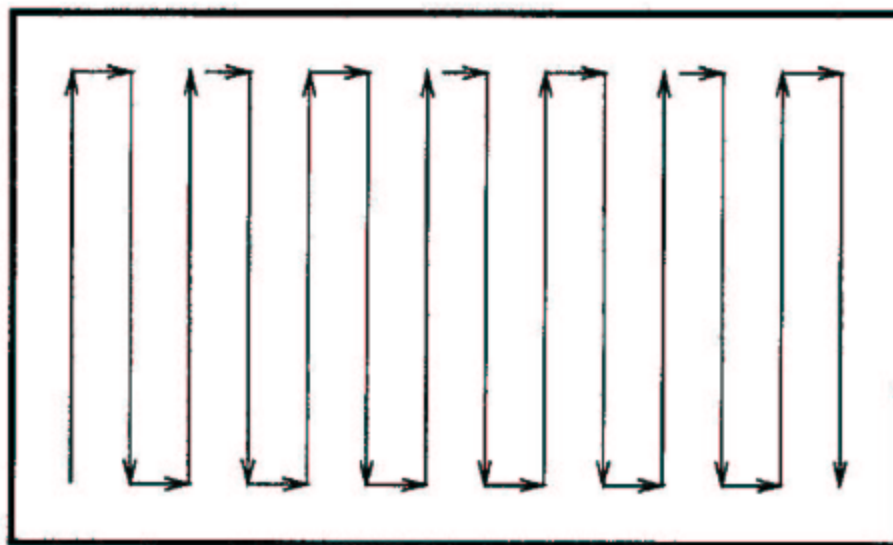


image borrowed from H. Choset, '01

Examples of Coverage

- 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.)

Doesn't work well for covering regions with obstacles

Lawn-mowing pattern

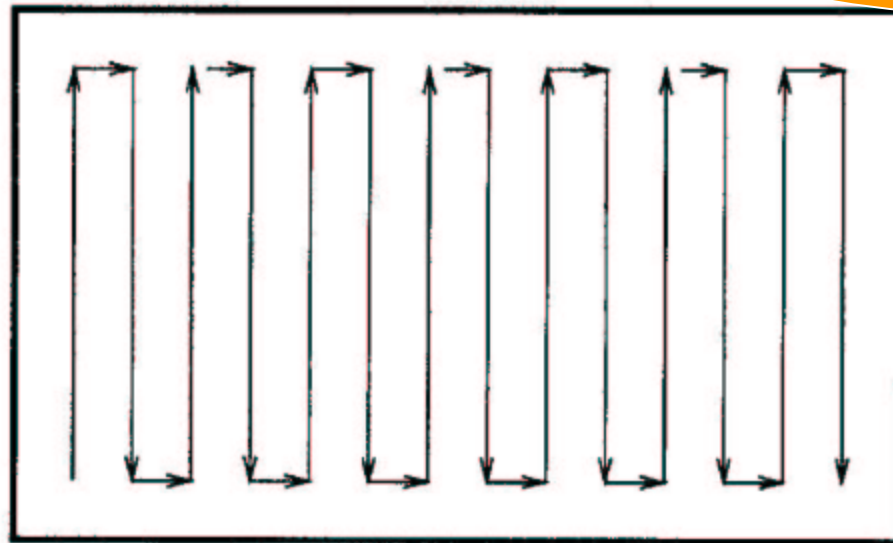
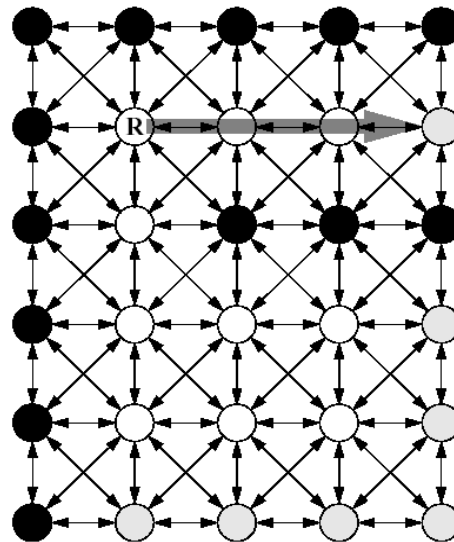
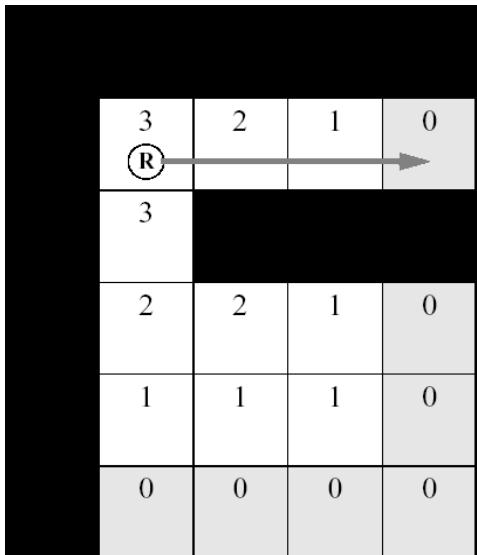


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Frontier-based Coverage

- 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?

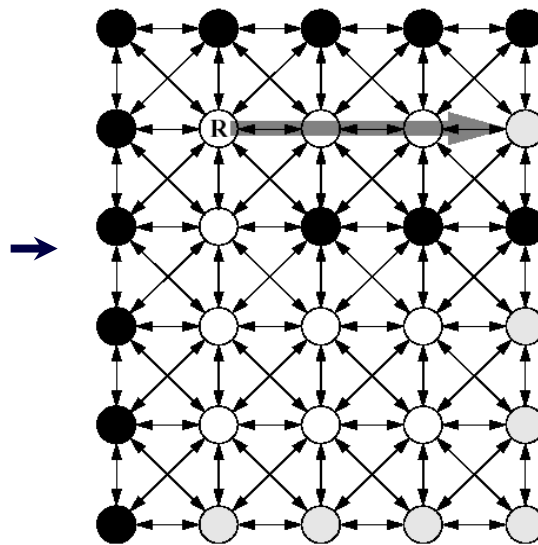
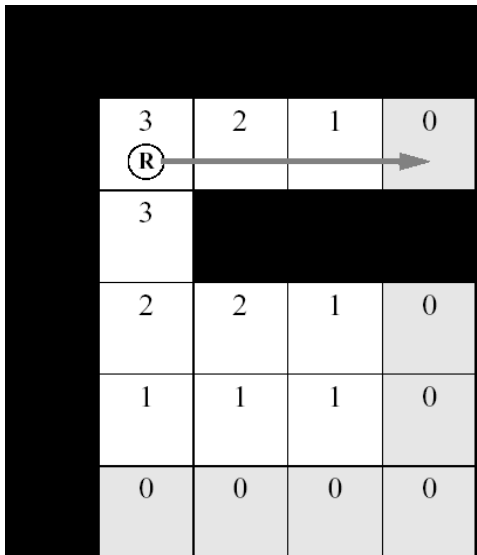


Frontier-based Coverage

- Always move the robot to the nearest cell that hasn't been “covered” (one of the frontier cells)

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

*How do you find a path to
the nearest “unobserved” cell?*

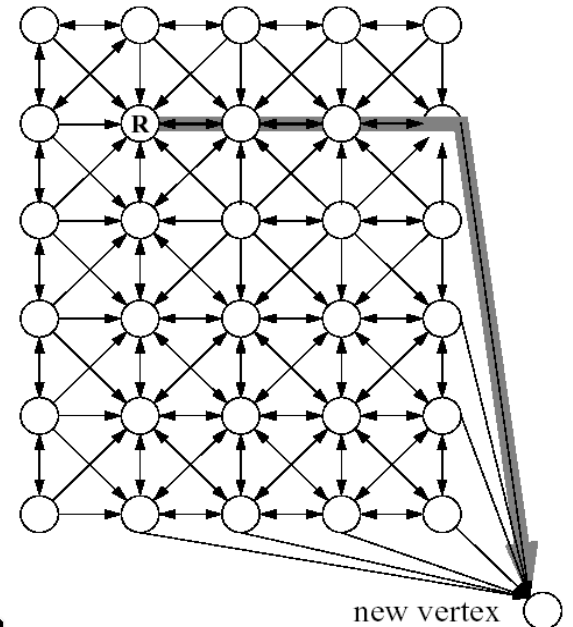
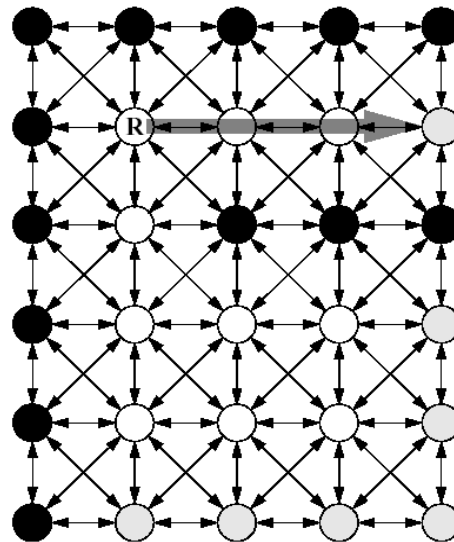
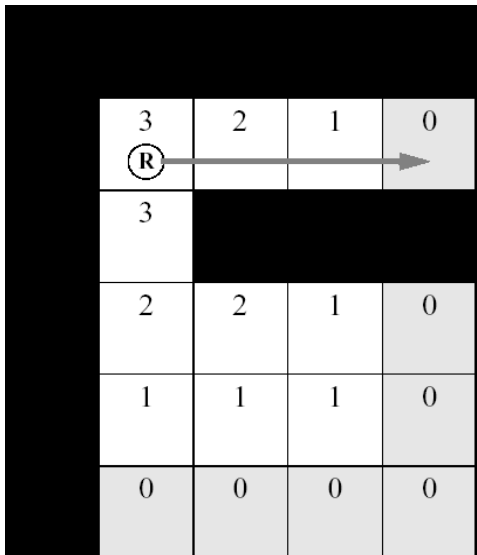


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Examples of Mapping

- 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

- Mapping

Any ideas on planning for mapping?

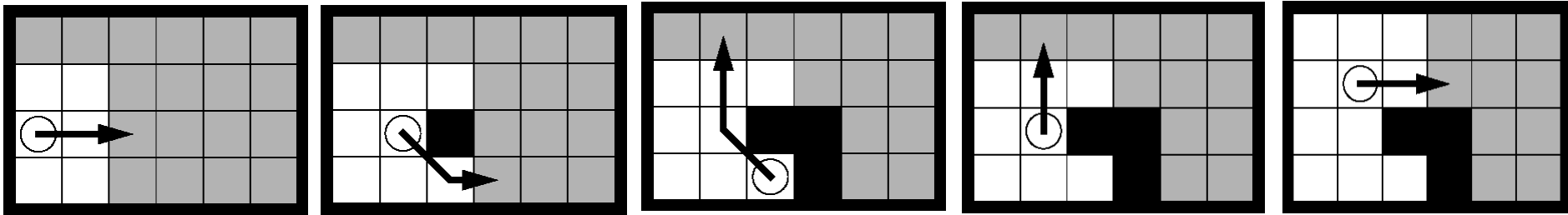
- Traversal of an unknown map using on-board sensors (e.g.

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



Greedy Mapping (Frontier-based method)

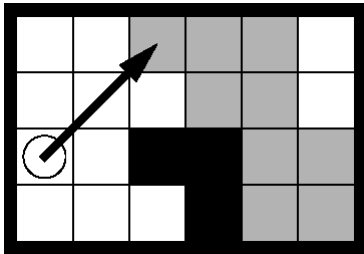
- Always move the robot on a shortest path to the closest unobserved (or unvisited) cell.



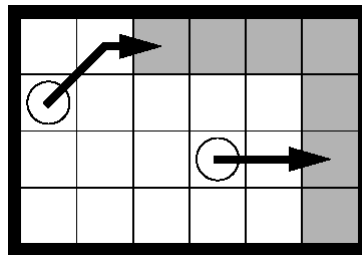
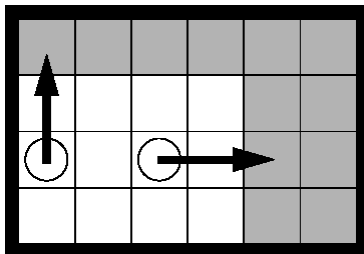
- *It always achieves a gain in information.*
- *Thus, it maps the terrain.*

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



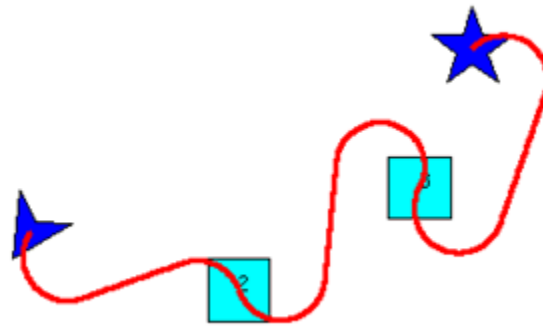
- *Can be used for mapping with multiple robots*



- *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)

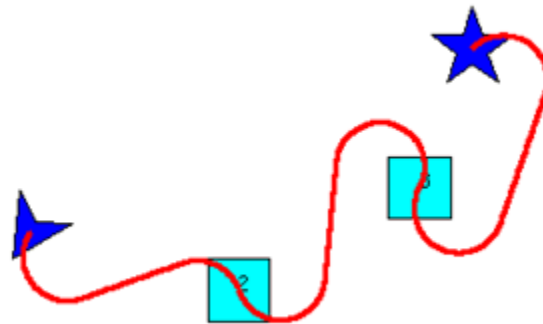


computing a least-cost path that visits all waypoints of interest (in any order) while being feasible (e.g., satisfies minimum turning radius, is collision-free, etc.)

Examples of Surveival

*How can we represent it
as a graph search?*

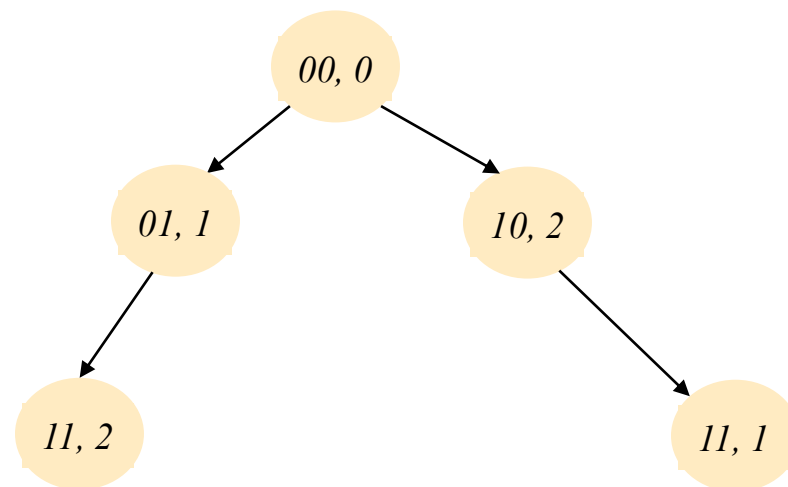
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Planning for Surveyal as Graph Search

- 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).

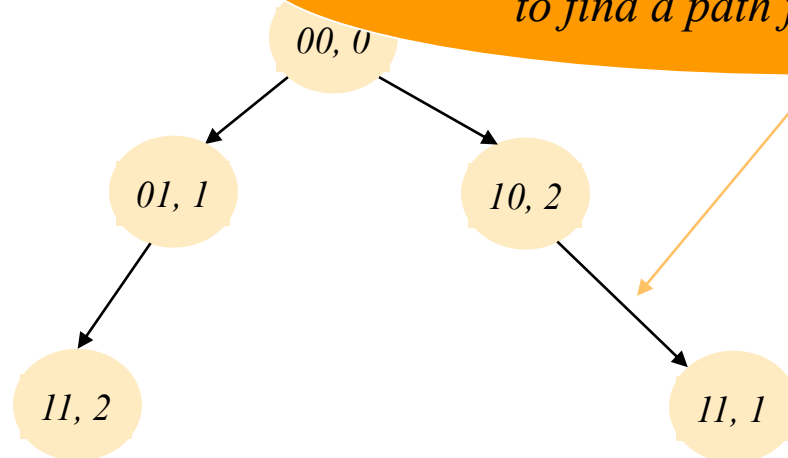


*Goal states:
all states where all waypoints have been visited*

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Each edge is a feasible path found by running a low-level motion planner to find a path from point A to B



*Goal states:
all states where all waypoints have been visited*

What You Should Know...

- What is coverage and what is mapping
- Frontier-based planning for coverage
- Frontier-based planning for mapping
- How to represent planning for surveyal as graph search