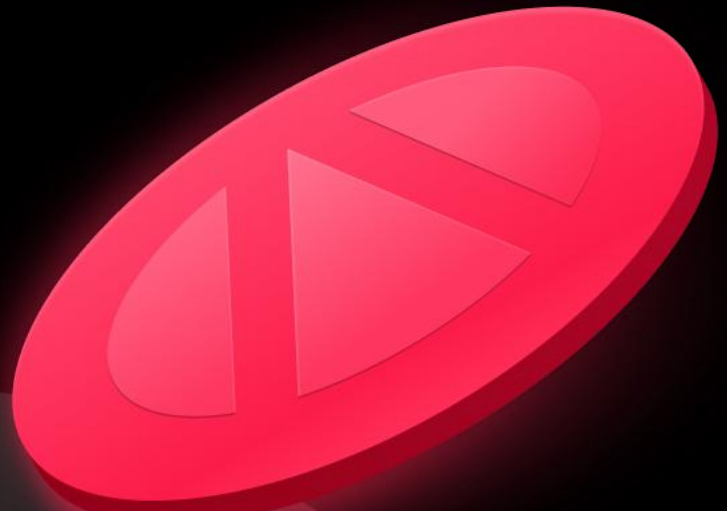
4-3 샘플링 기법 2: Obstacle-Based Probabilistic Roadmap (OB-PRM)



강의 요약

01

Probabilistic Roadmap (PRM)

연속적인 C-Space 를
불연속적인 그래프로 변형

02

주요 특징

- Multi-query
- Narrow Passage
- 최적 경로 보장 X
- Probabilistically Complete

03

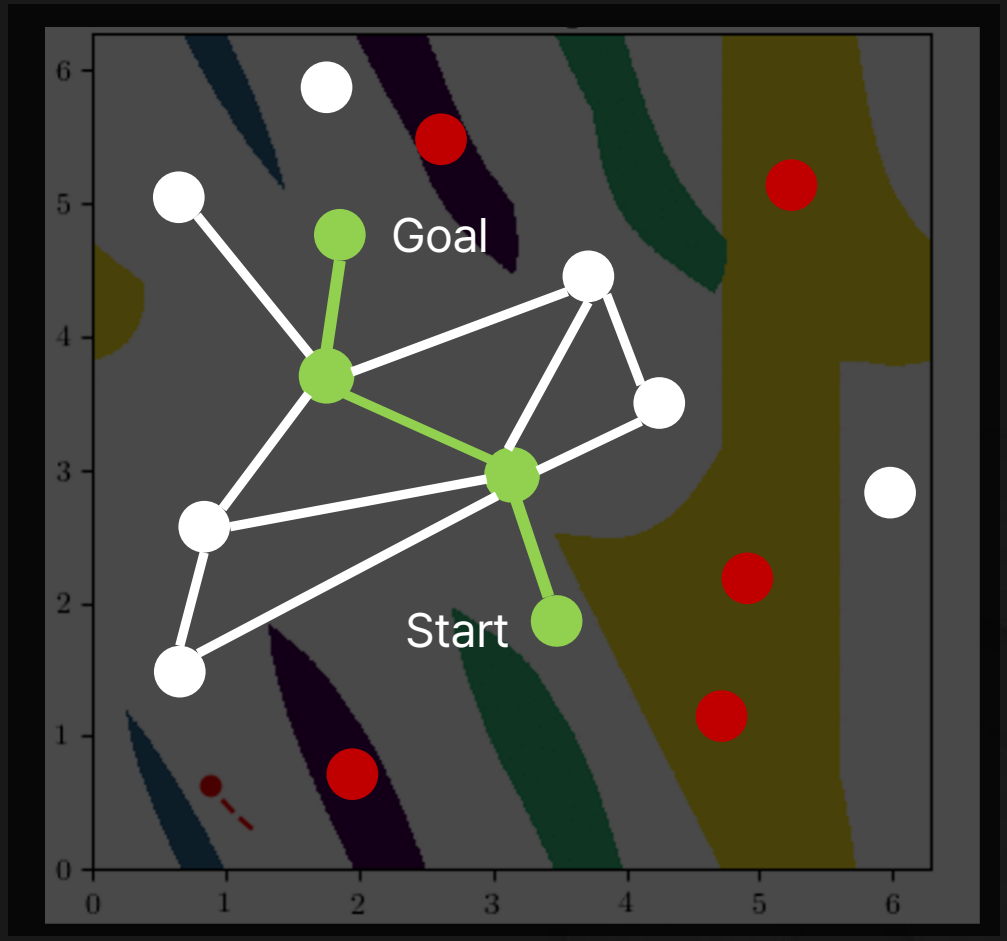
알고리즘

04

코드 분석

Probabilistic Roadmap (PRM)

- 샘플링을 통해서 C-Space 를 근사 (approximate)
- 연속적인 C-Space 를 불연속적인 그래프로 변형
- 주요 특징
  - Narrow Passage
  - 샘플링 방법에 따라 성능이 결정 됨



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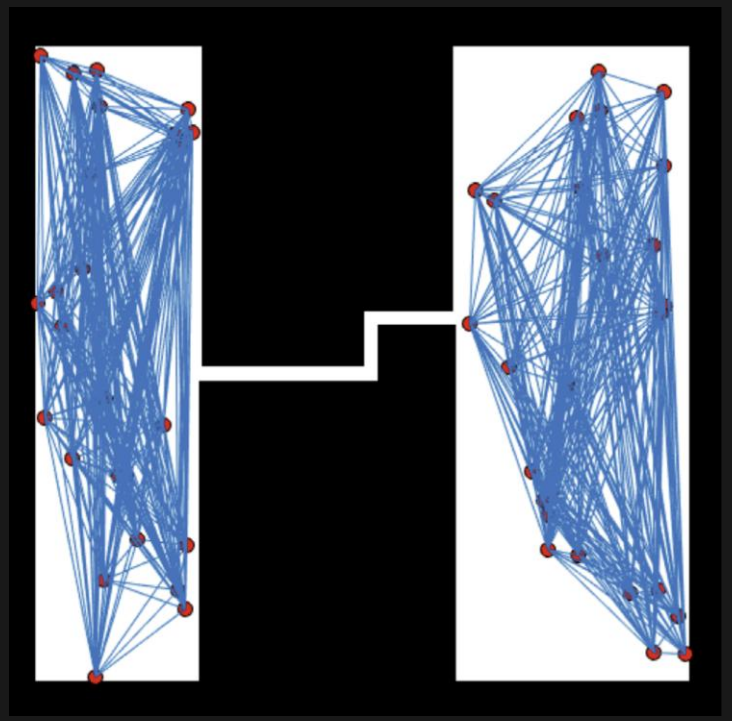
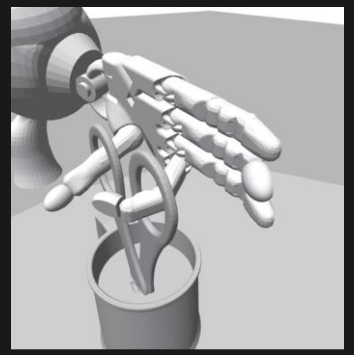
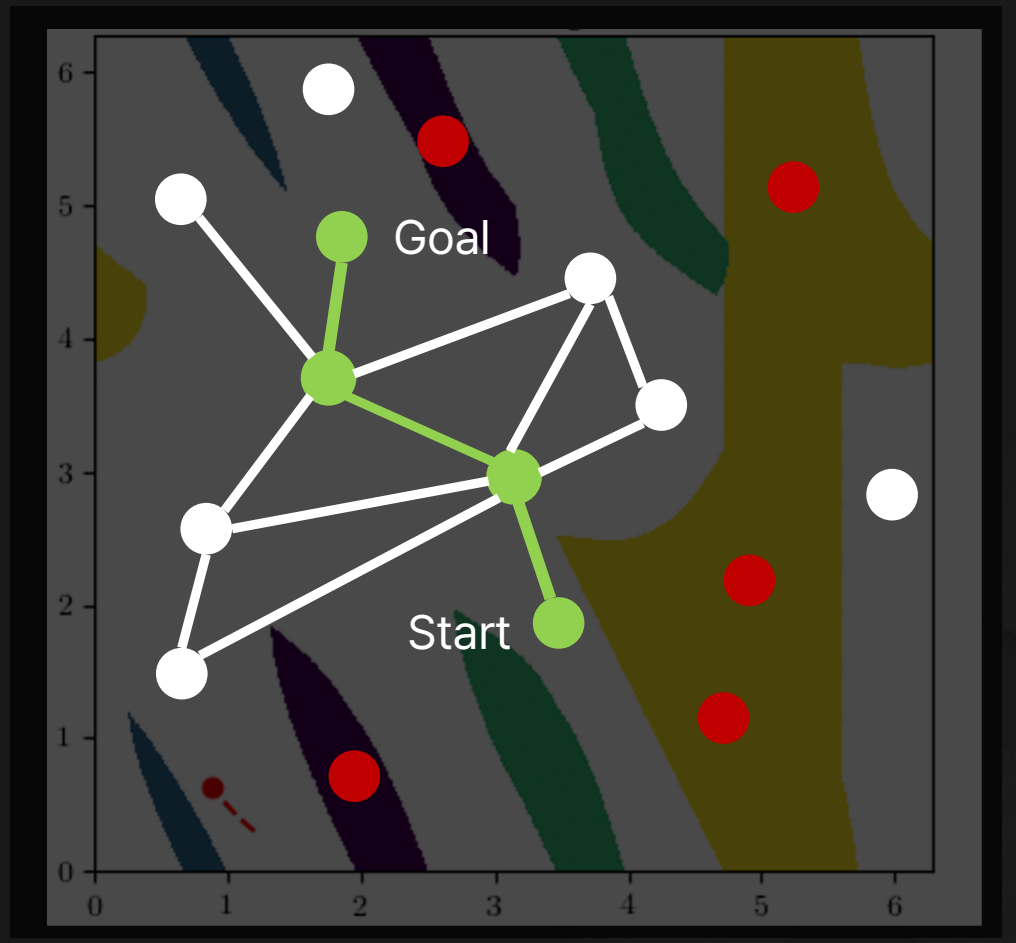


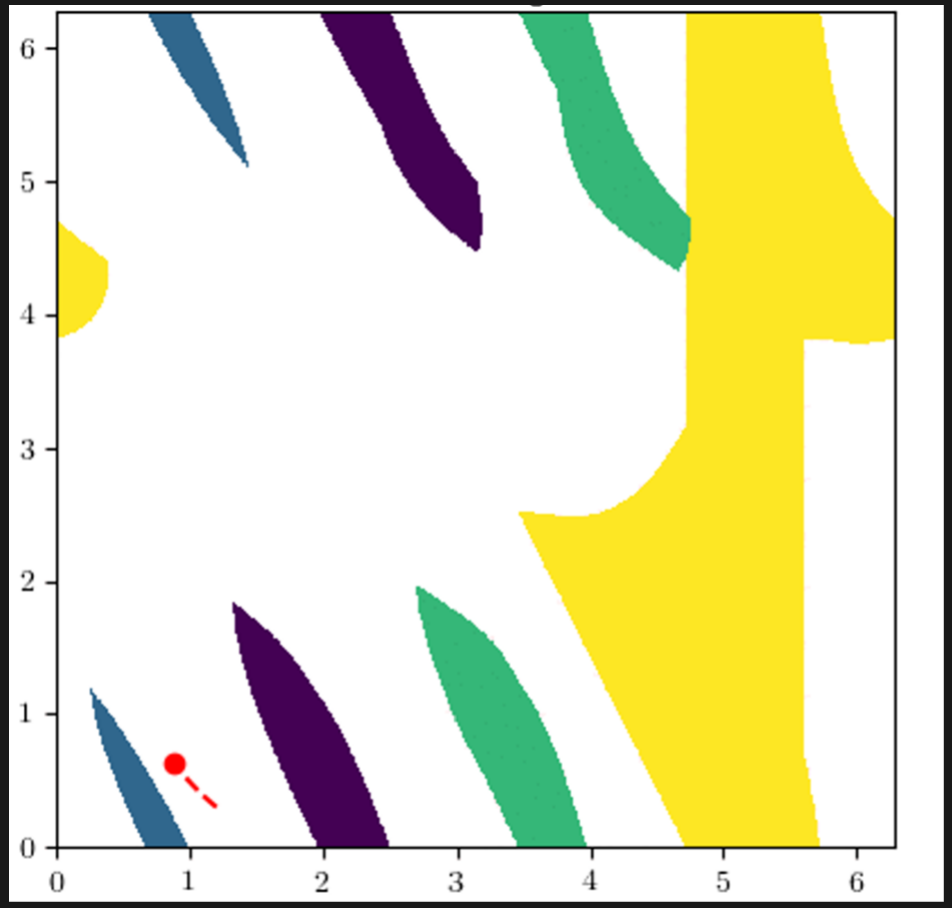




Robot path planning in narrow passages based on improved PRM method
Section Patterns: Efficiently Solving Narrow Passage Problems in Multilevel Motion Planning

Obstacle-Based Probabilistic Roadmap (OB-PRM)

- C-obstacle 근처 샘플링에 집중



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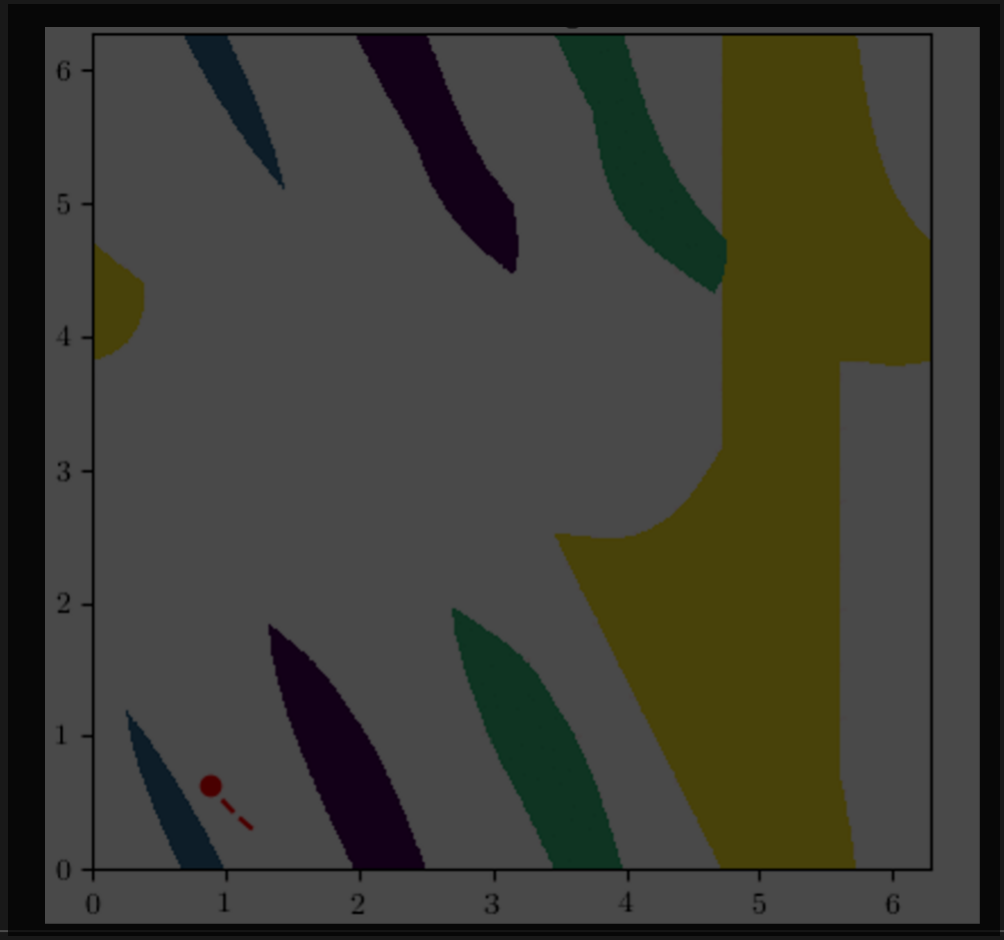

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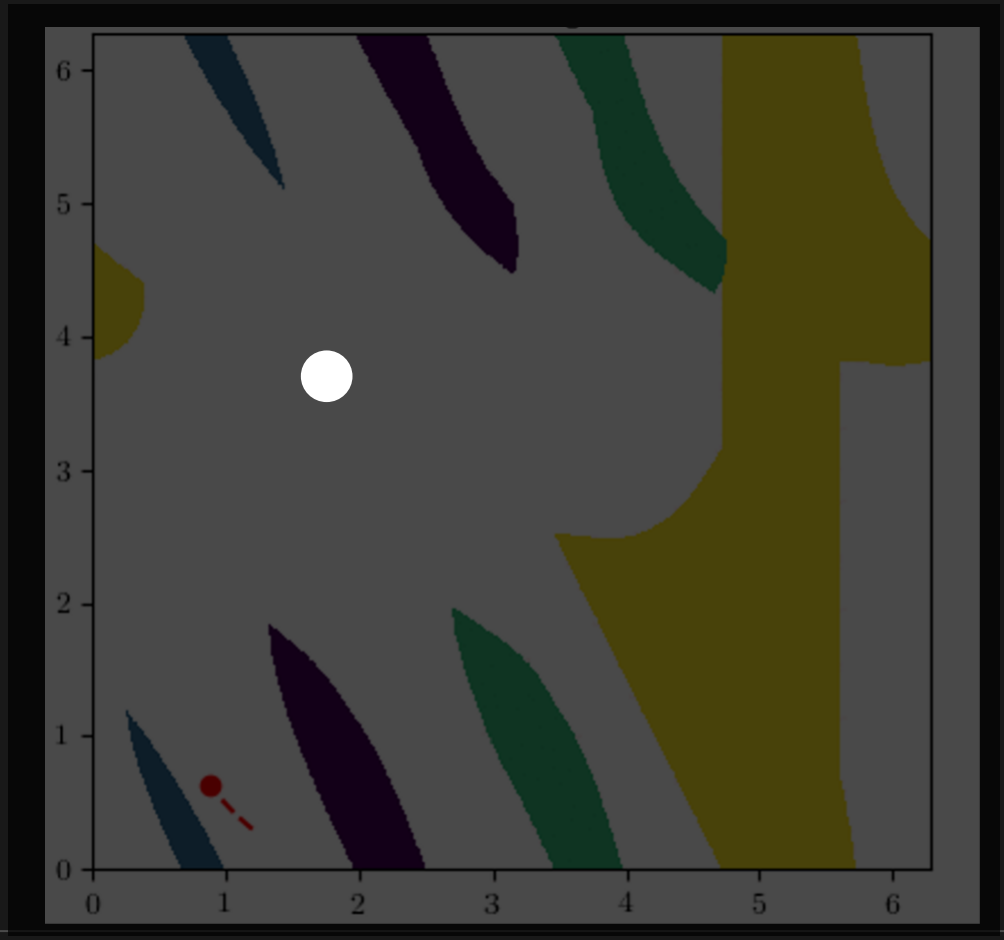

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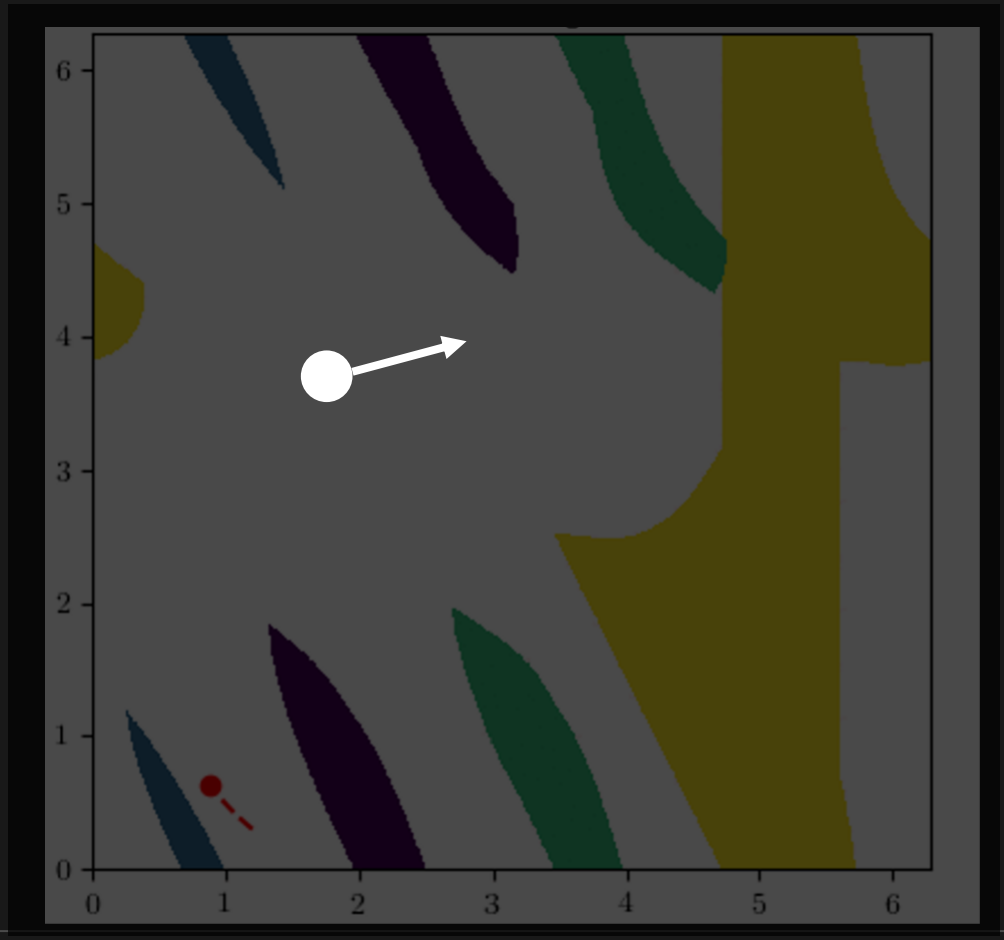

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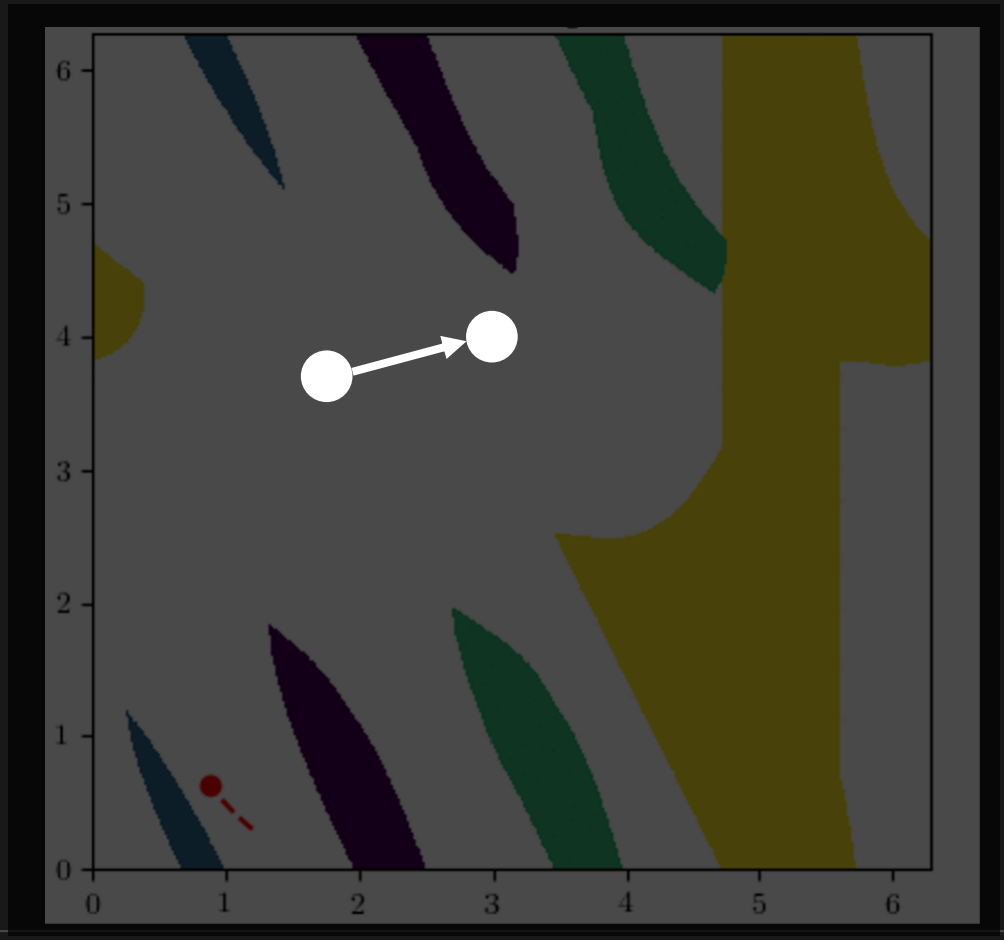

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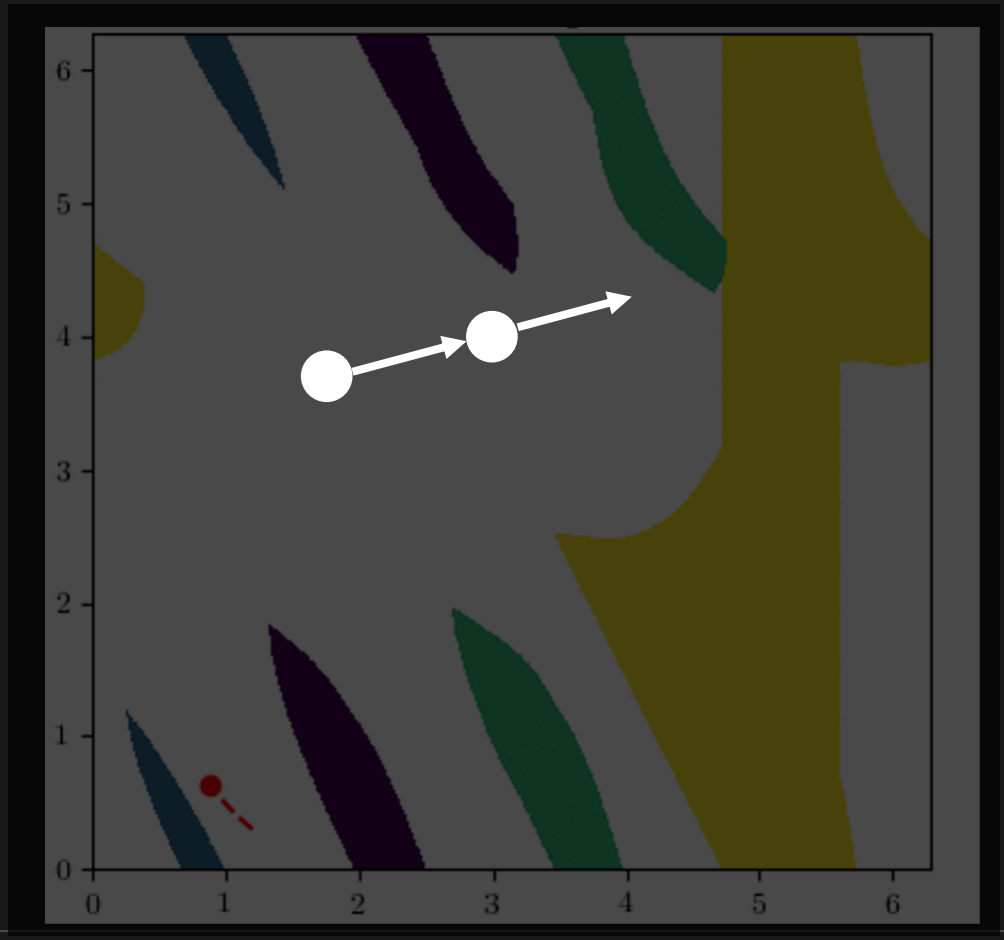

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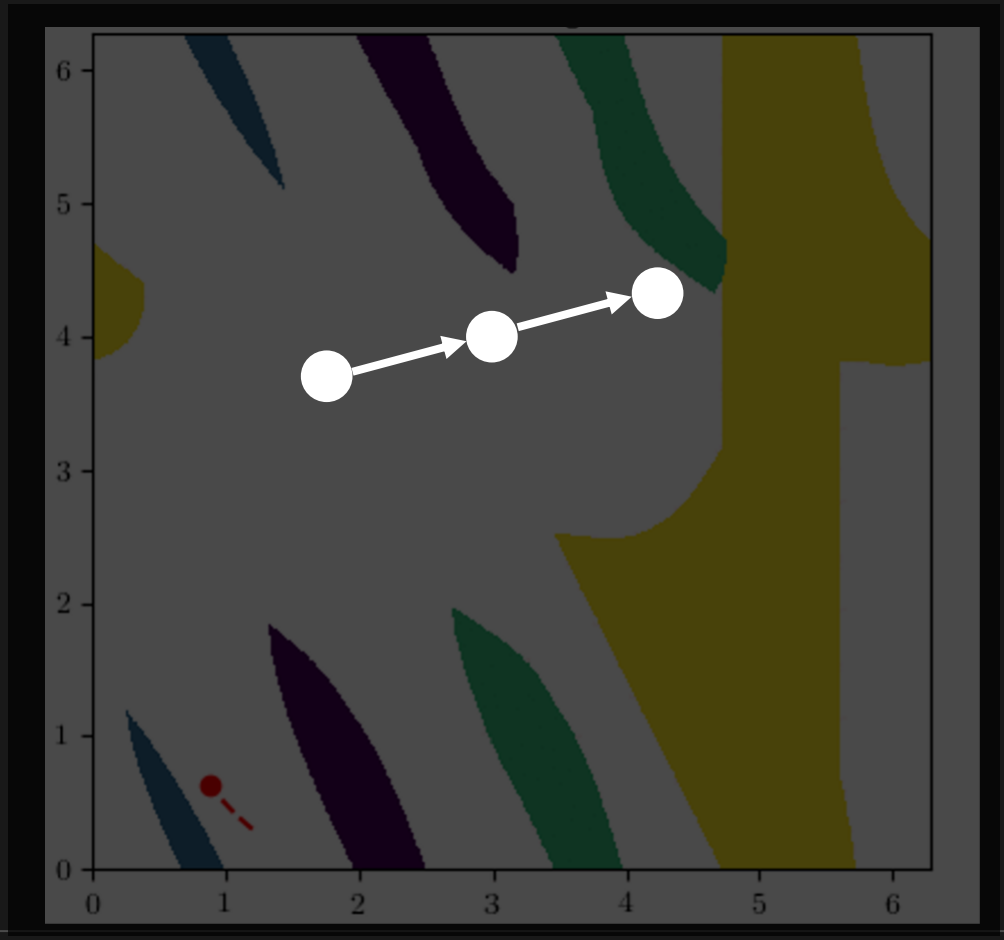

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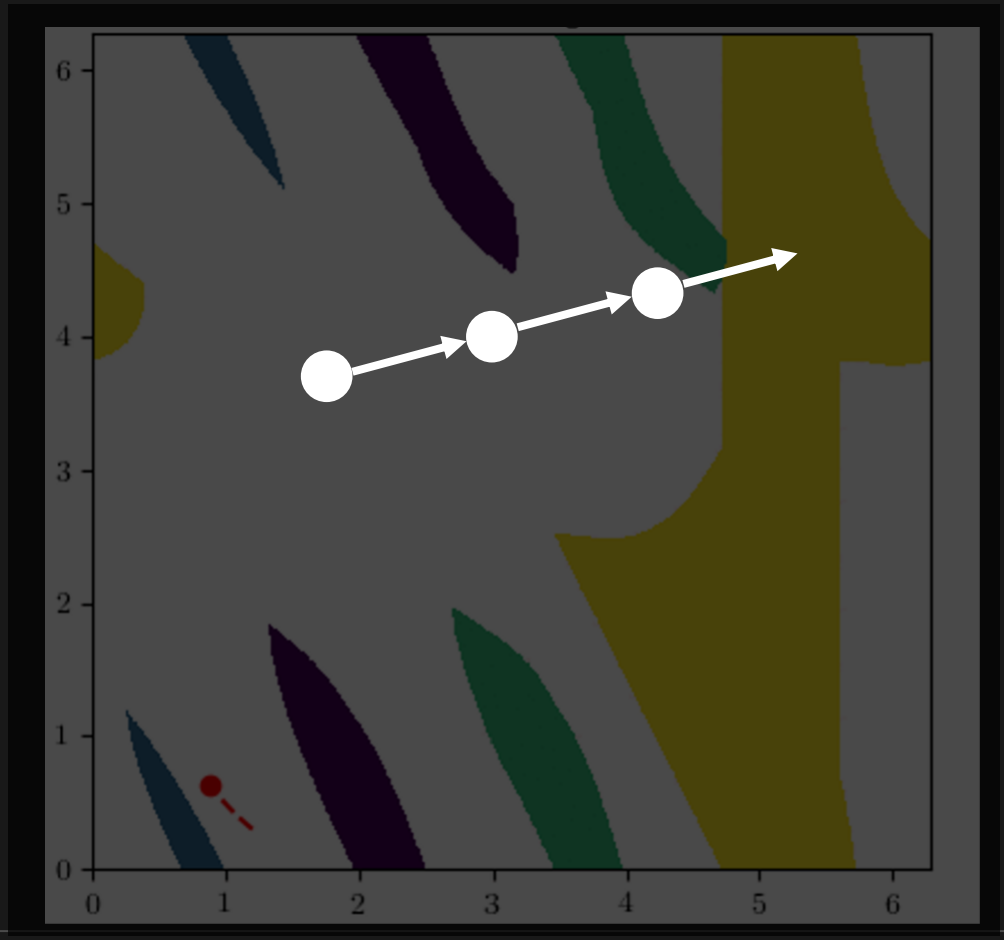

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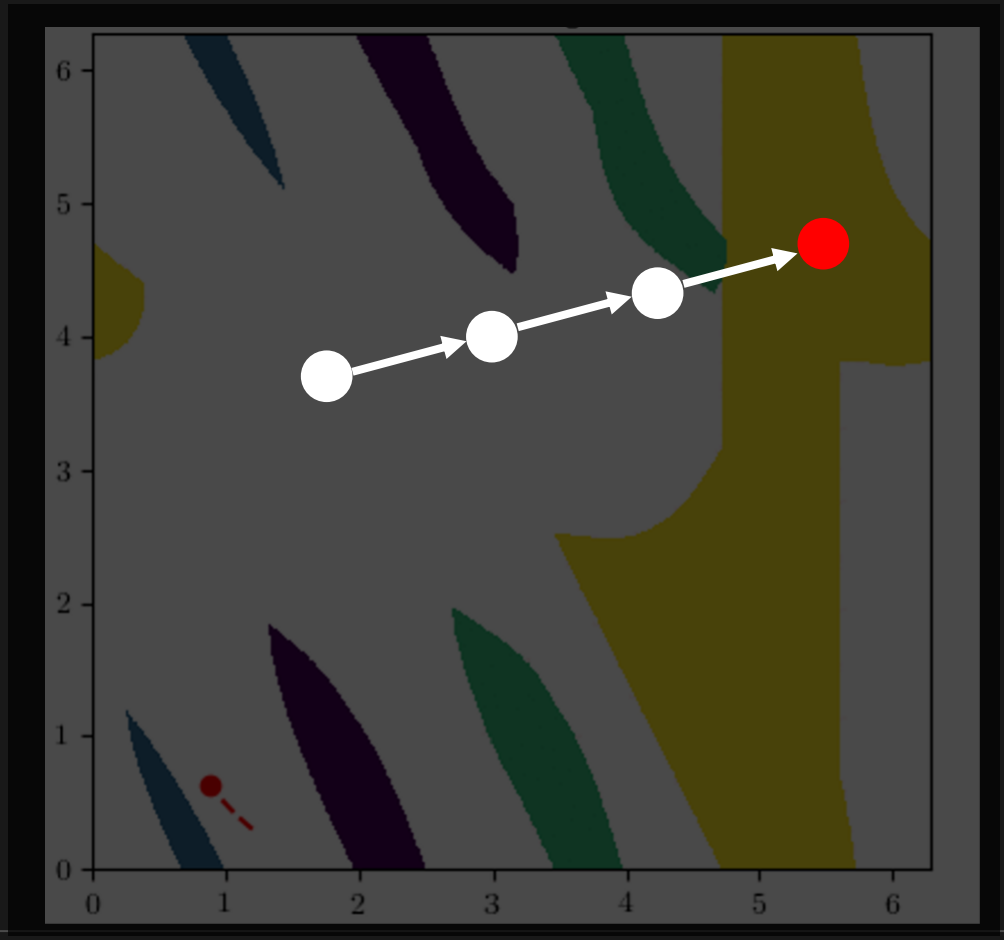

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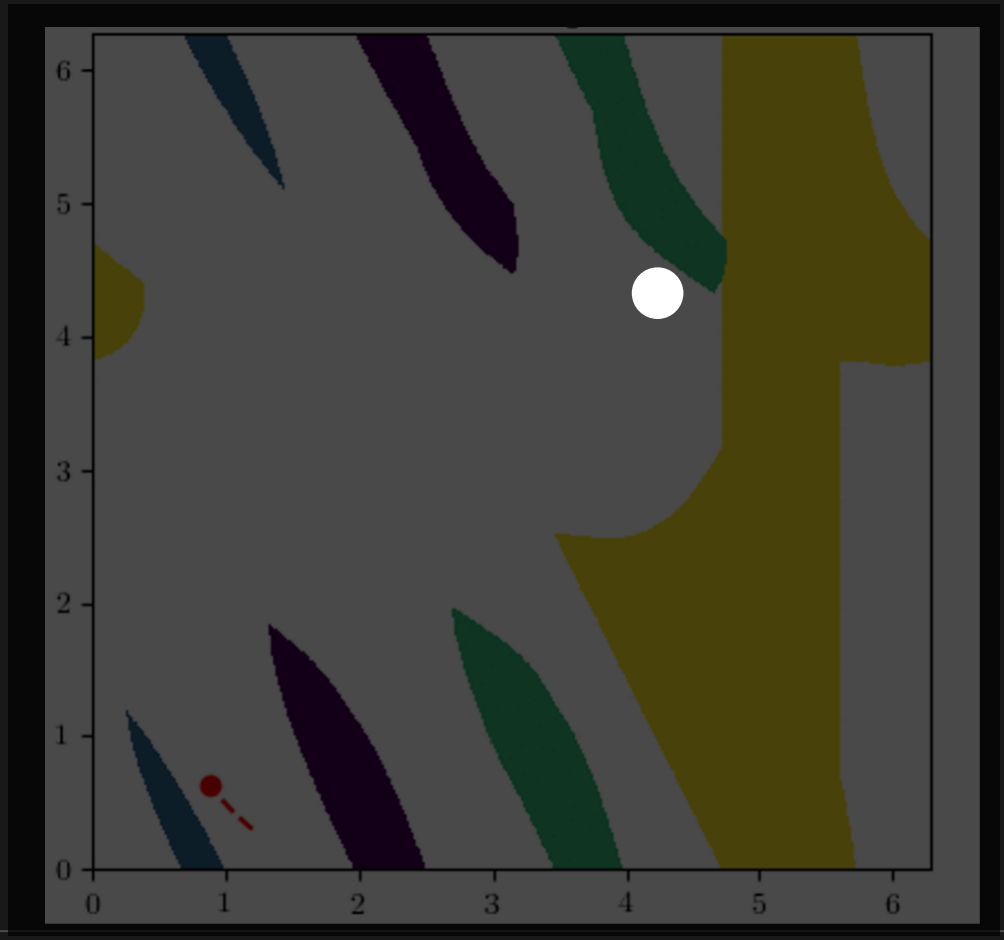

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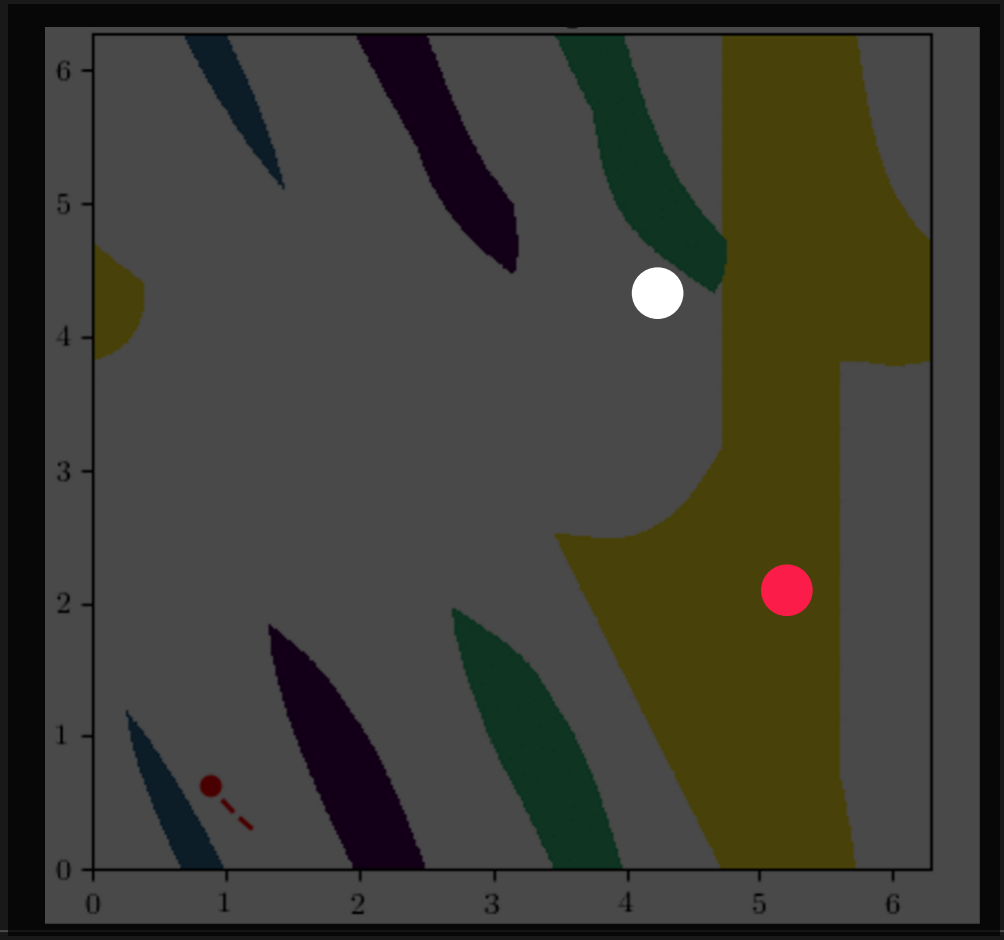

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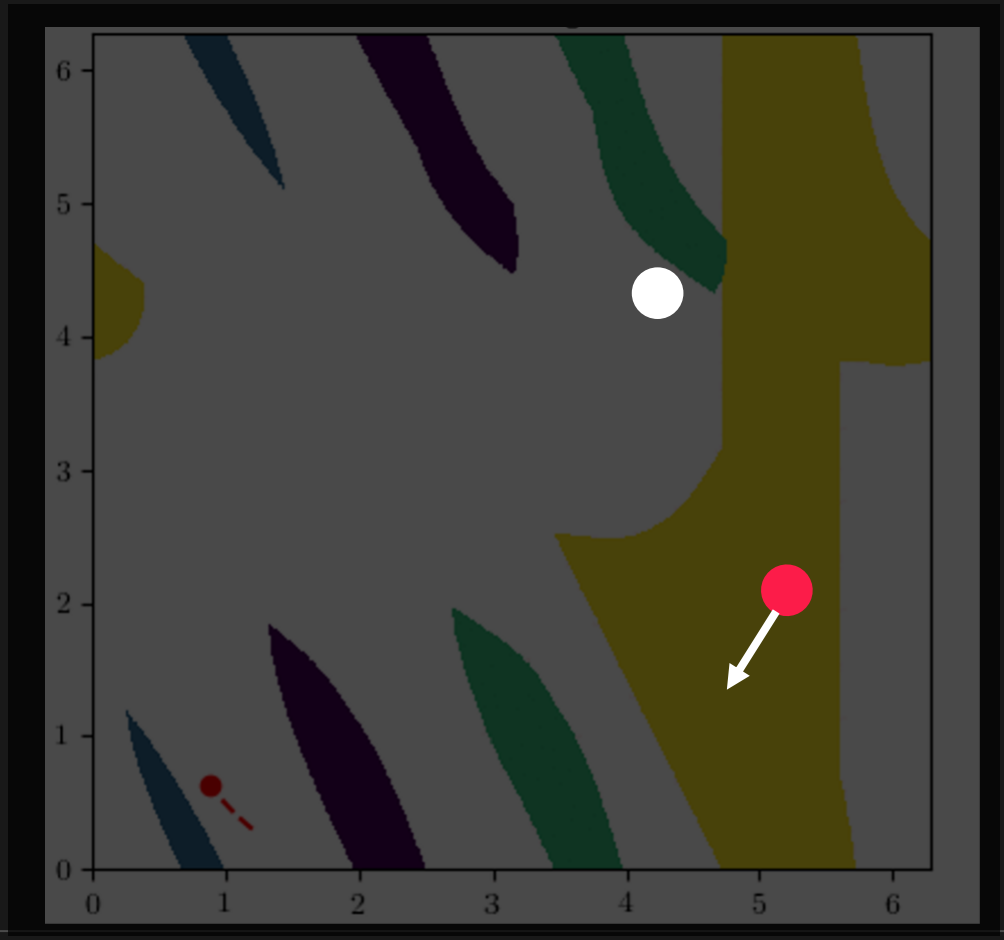

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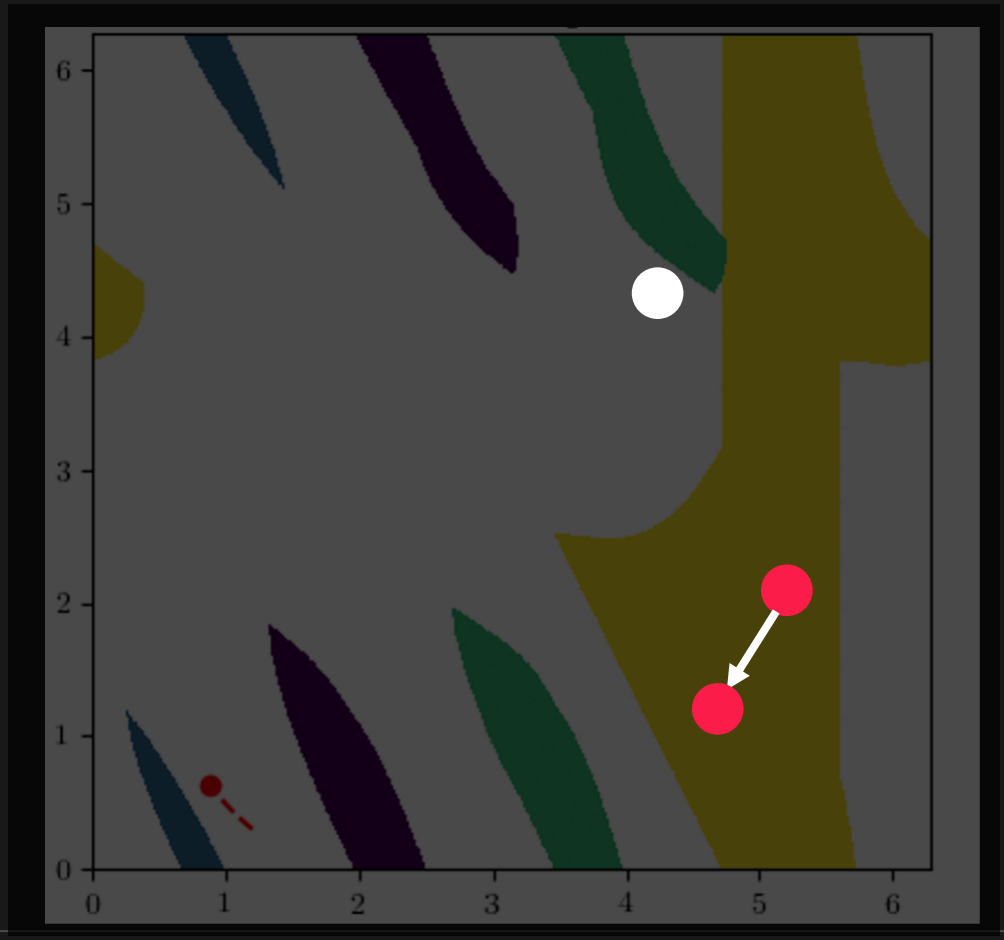

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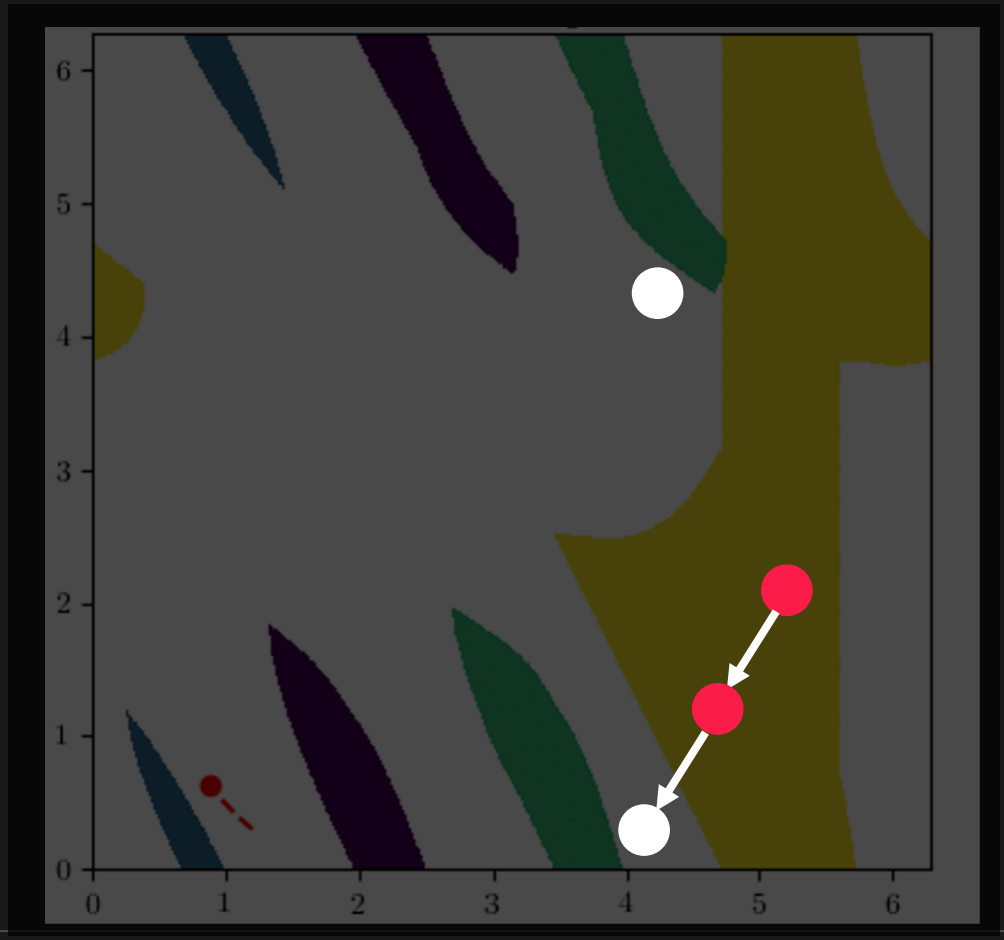

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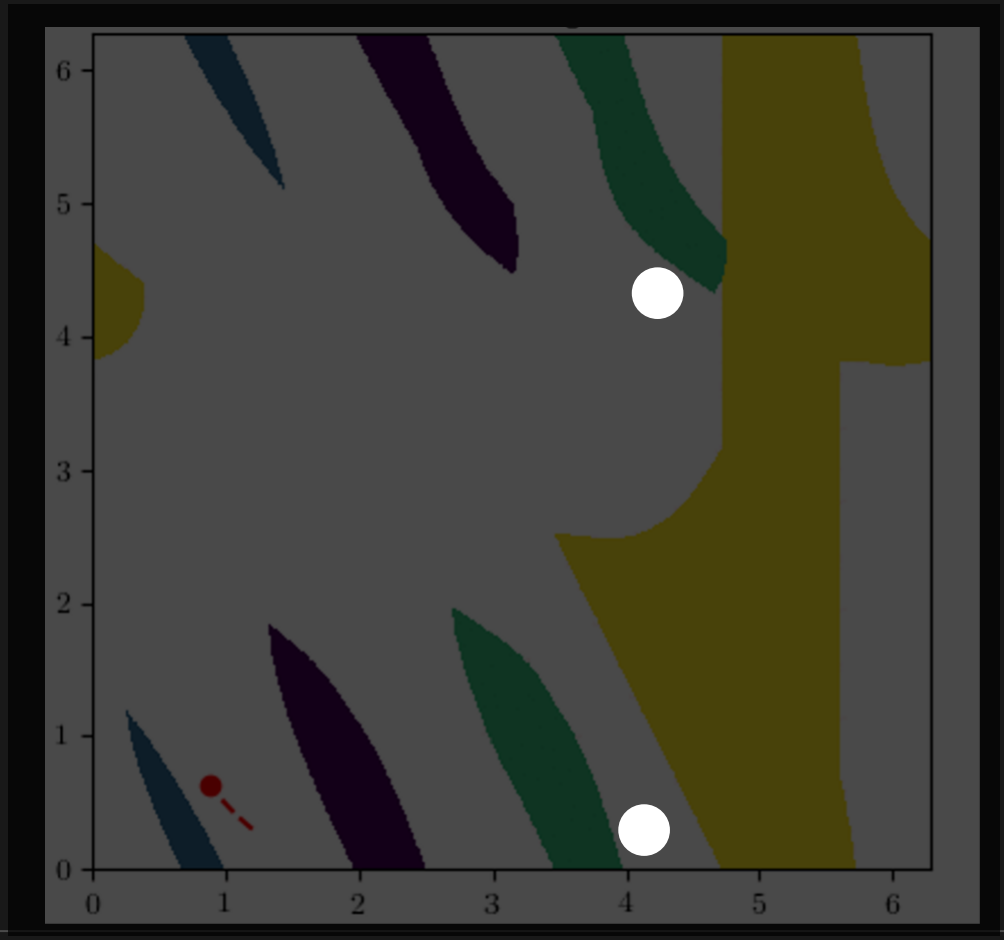

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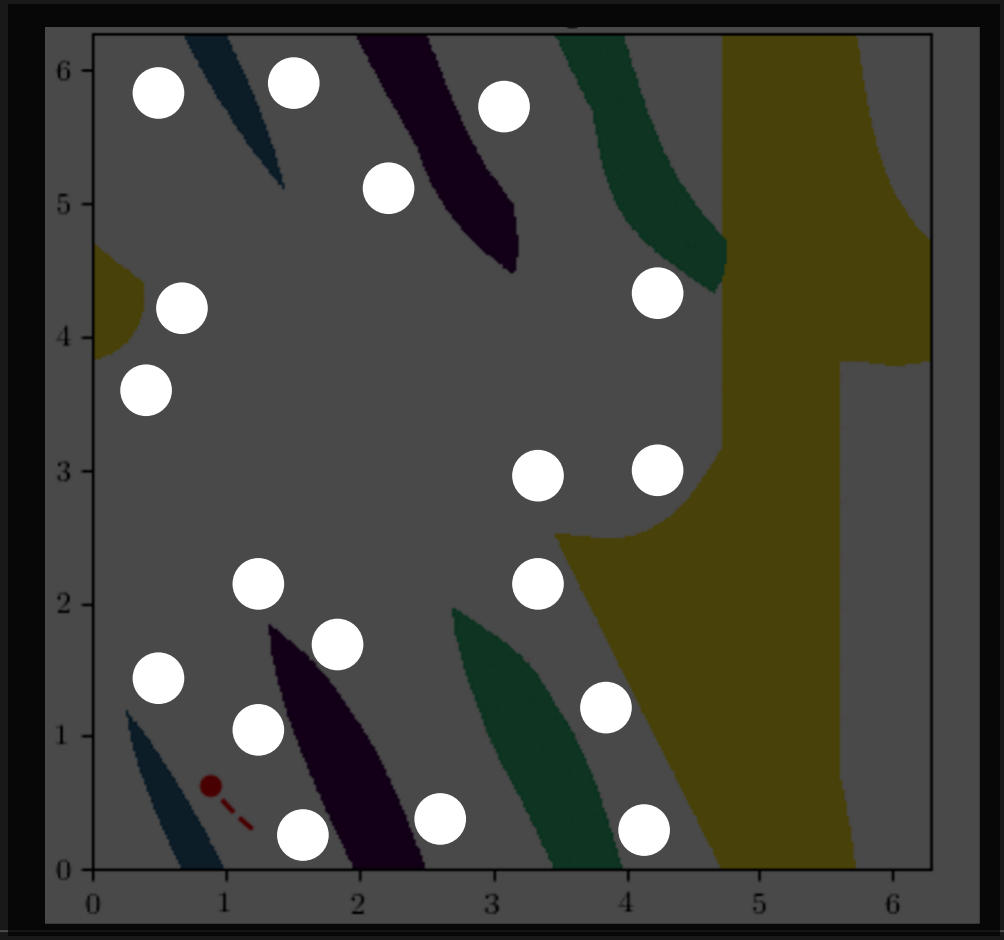

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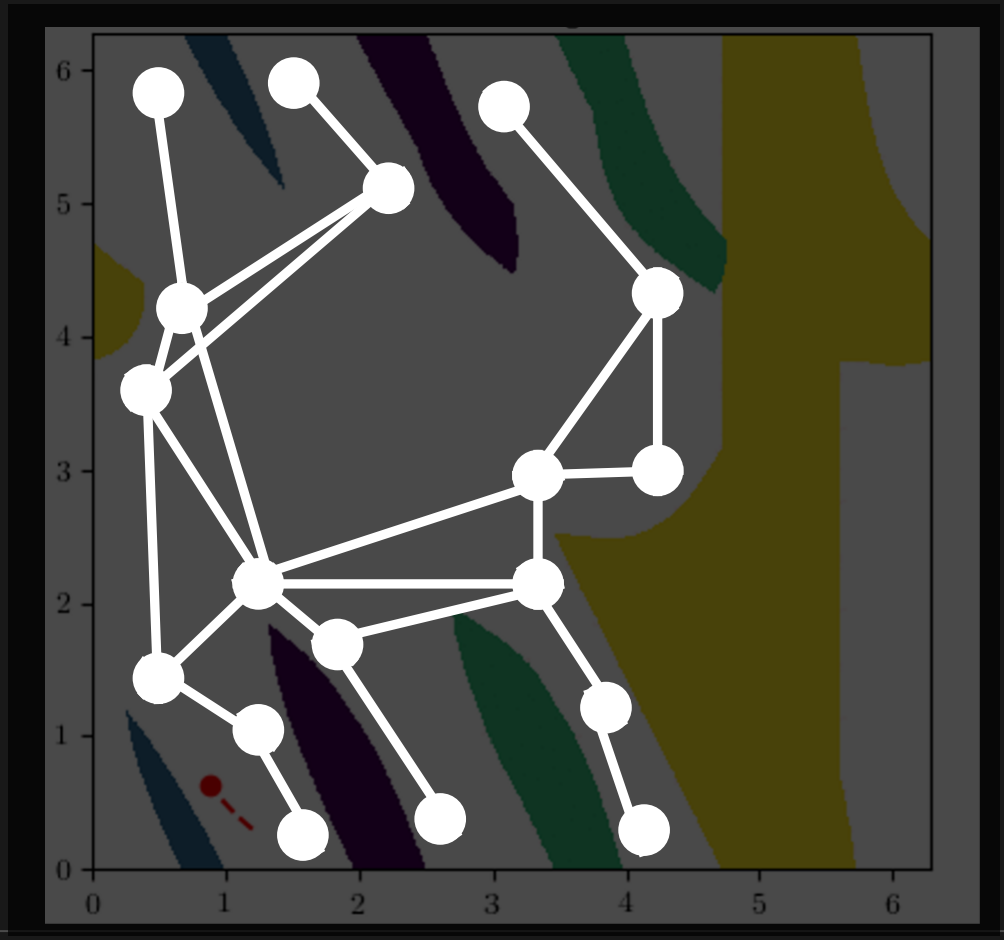

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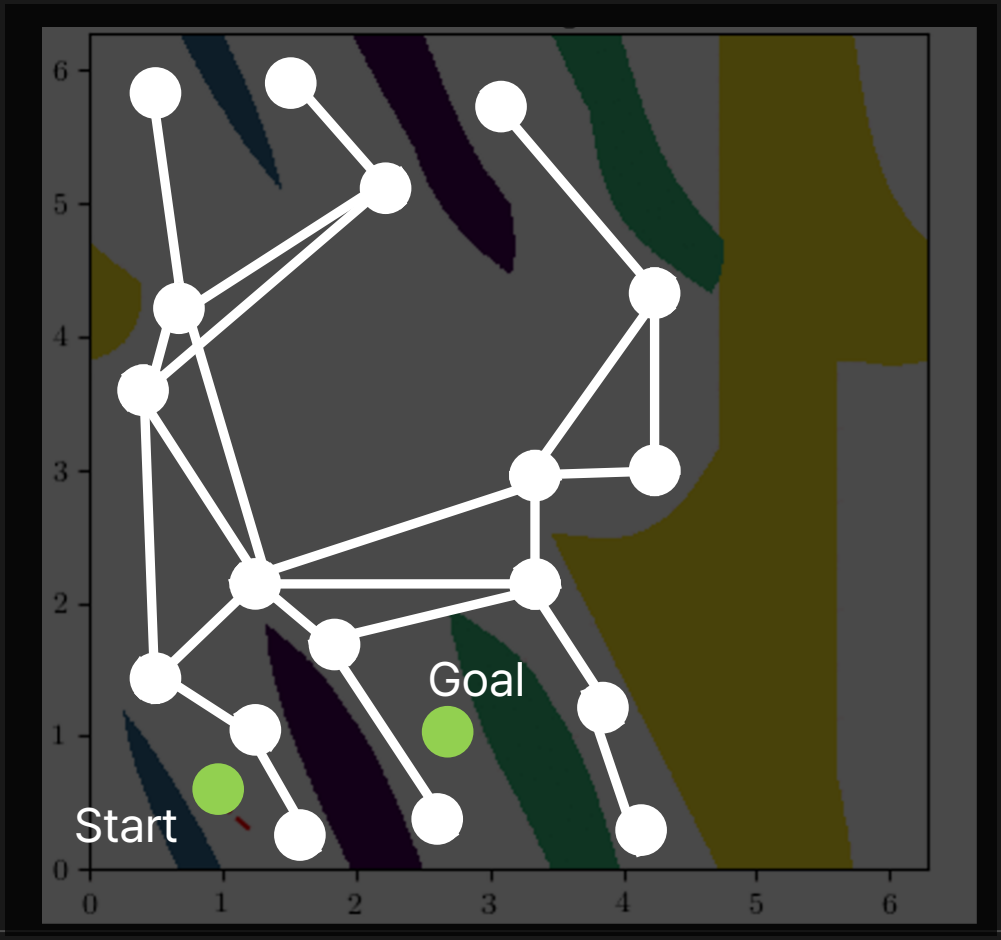

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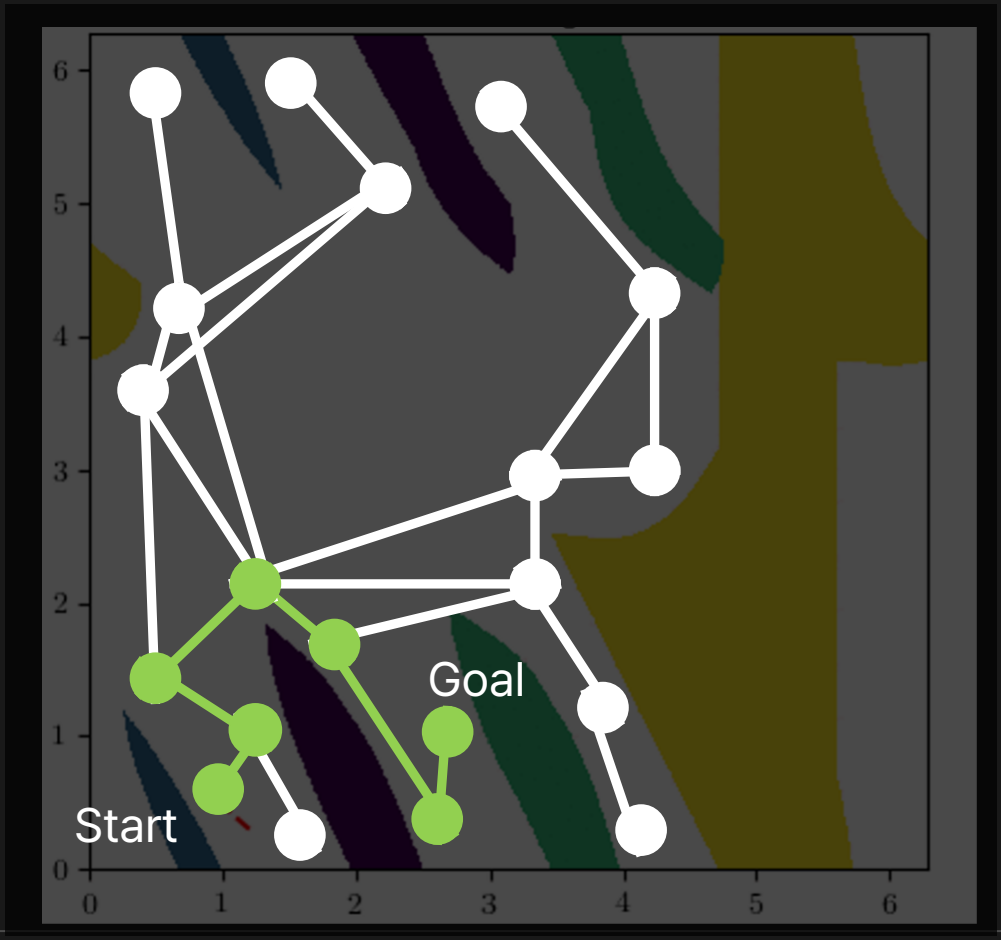

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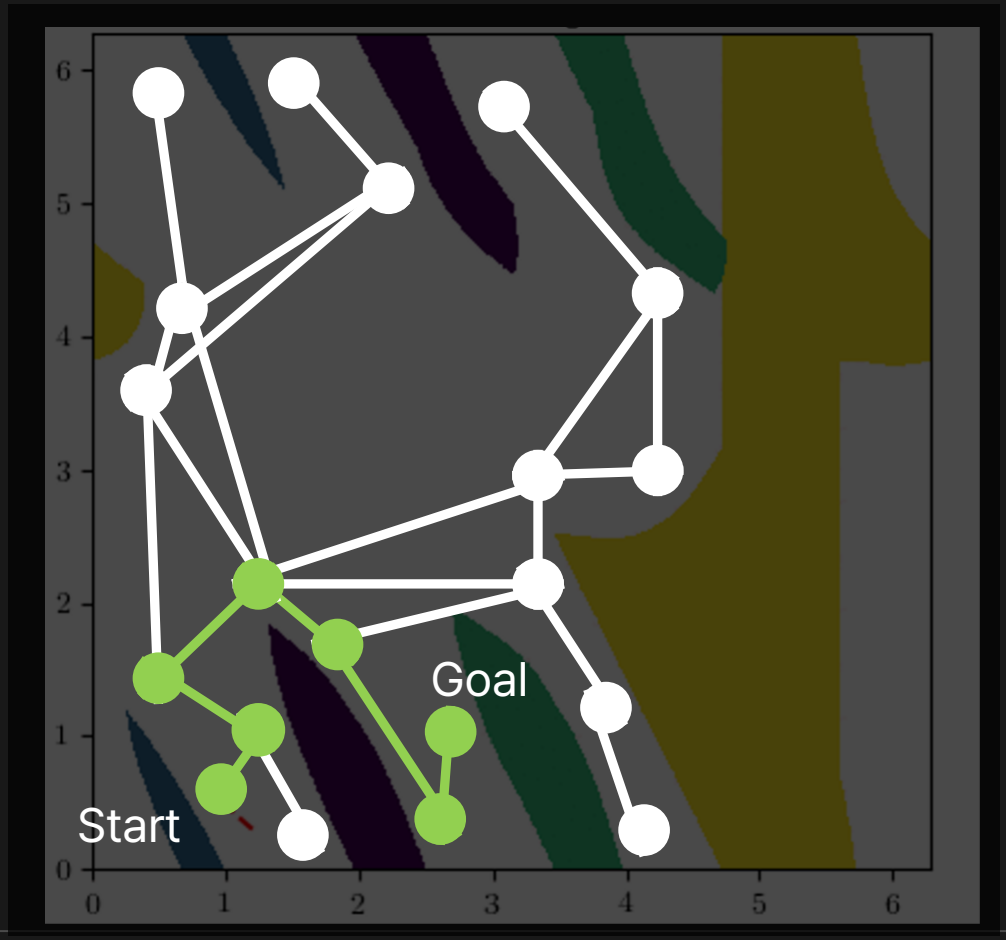
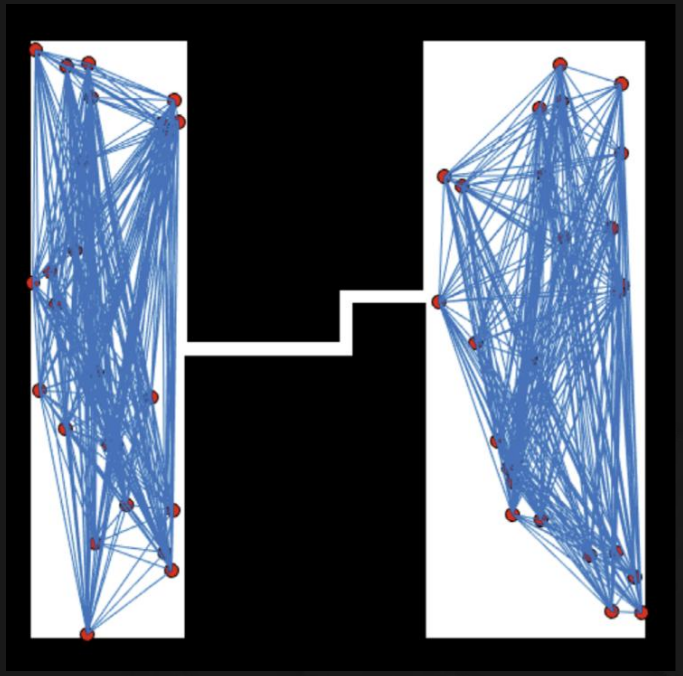
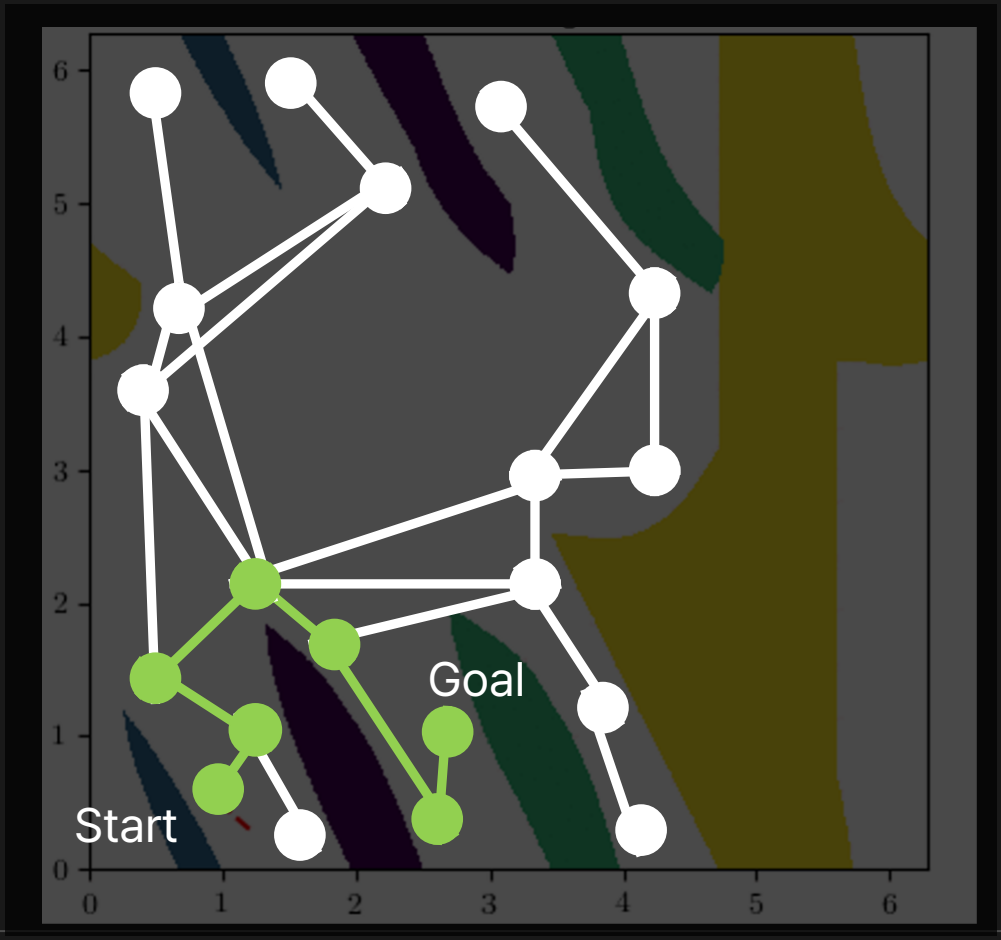




Obstacle-Based Probabilistic Roadmap (OB-PRM)

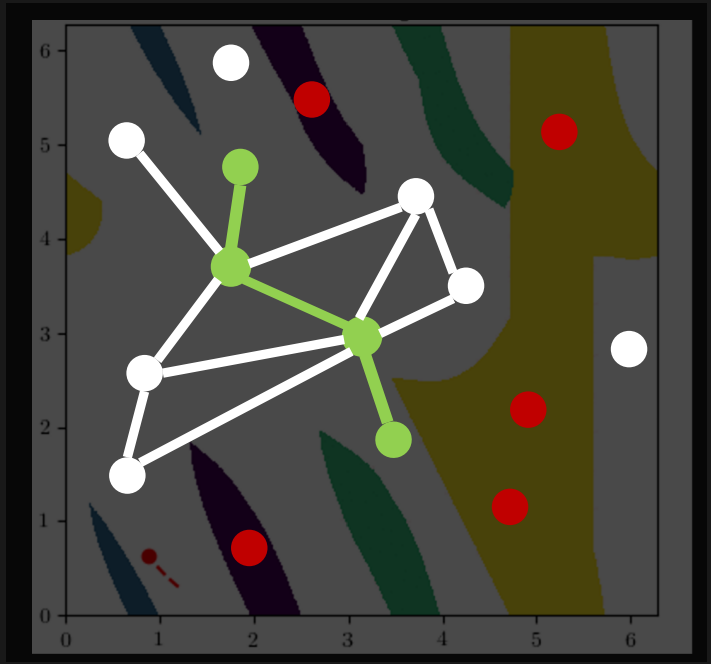
- C-obstacle 근처 샘플링에 집중

- 주요 특징
  - Multi-query
  - Narrow Passage
  - 최적의 경로 보장 X
  - Probabilistically Complete



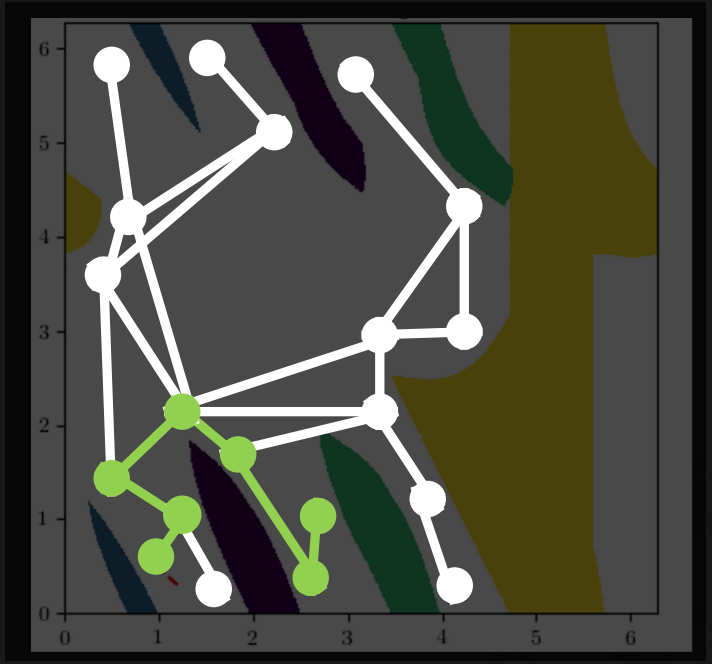
PRM vs. OB-PRM

PRM



- Narrow Passage :(
- 충돌 검출 횟수가 비교적 적음

OB-PRM



- Narrow Passage :)
- 충돌 검출 횟수가 비교적 많음

Obstacle-Based Probabilistic Roadmap (OB-PRM)

Algorithm 1 Probabilistic Roadmap (PRM)

Require: Number of samples N, number of neighbors k, start q_{start}, goal q_{goal}
Ensure: A path from q_{start} to q_{goal}, if one exists

Initialize roadmap graph $G = (V, E) \leftarrow \emptyset$

while $|V| < N$ **do**
    Sample a random configuration $q \in \mathcal{C}$
    if $q \in \mathcal{C}_{\text{free}}$ **then**
        $V \leftarrow V \cup \{q\}$
    end if
end while
for all $q \in V$ **do**
    Find k-nearest neighbors $\text{NN}_k(q) \subset V$
    for all $q_{\text{near}} \in \text{NN}_k(q)$ **do**
        if LocalPlanner(q, q_{near}) is collision-free **then**
            $E \leftarrow E \cup \{(q, q_{\text{near}})\}$
        end if
    end for
end for

if $q_{\text{start}}, q_{\text{goal}} \in \mathcal{C}_{\text{free}}$ **then**
    $V \leftarrow V \cup \{q_{\text{start}}, q_{\text{goal}}\}$
    Connect $q_{\text{start}}, q_{\text{goal}}$ to k-nearest neighbors with collision-free edges
    Use graph search (e.g., Dijkstra or A*) to find path from q_{start} to q_{goal}
else
    return No valid path (start or goal in collision)
end if

Algorithm 2 Obstacle-Based PRM (OBPRM)

Require: Number of samples N, number of neighbors k
Ensure: Roadmap graph $G = (V, E)$

Initialize roadmap $G = (V, E) \leftarrow \emptyset$

while $|V| < N$ **do**
    Sample a random configuration $q \in \mathcal{C}$
    if $q \in \mathcal{C}_{\text{obs}}$ **then**
        Generate random direction d
        for $i = 1$ to m **do**
            $q' \leftarrow q + \epsilon_i d$
            if $q' \in \mathcal{C}_{\text{free}}$ **then**
                $V \leftarrow V \cup \{q'\}$
                break
            end if
        end for
    end if
end while
for all $q \in V$ **do**
    Find k-nearest neighbors $\text{NN}_k(q) \subset V$
    for all $q_{\text{near}} \in \text{NN}_k(q)$ **do**
        if LocalPlanner(q, q_{near}) is collision-free **then**
            $E \leftarrow E \cup \{(q, q_{\text{near}})\}$
        end if
    end for
end for

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else
    return No valid path (start or goal in collision)
end if

강의 요약

01

Obstacle-Based Probabilistic Roadmap (OB-PRM)

- PRM 과 샘플링 기법에서 차이
- C-obstacle 근처에 샘플링

02

주요 특징

- Multi-query
- Narrow Passage :)
- 최적 경로 보장 X
- Probabilistically Complete
- 충돌검출 횟수 비교적 많음

03

알고리즘

04

코드 분석