

# ToD & DyP :

## A Planning Solution for Efficient Navigation in Changing Environments

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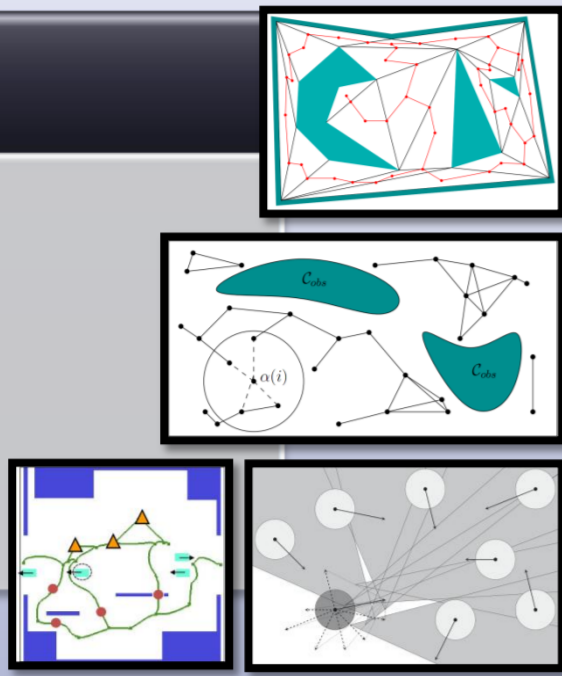
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### Problem statement

Path Planning has been widely studied in robotics to provide robots with autonomy of navigation.

#### Classical methods

- Static Environments
- Cell decomposition
- Probabilistic methods
- Dynamic Environments
- Velocity obstacles
- Lazy PRMs coupled with RRTs



#### Limitations

- Most solutions focus on static environments
- Most methods for dynamic environments consider moving objects as obstacles
- No solution was proposed to navigate on moving / movable objects to access previously unreachable parts of the environment

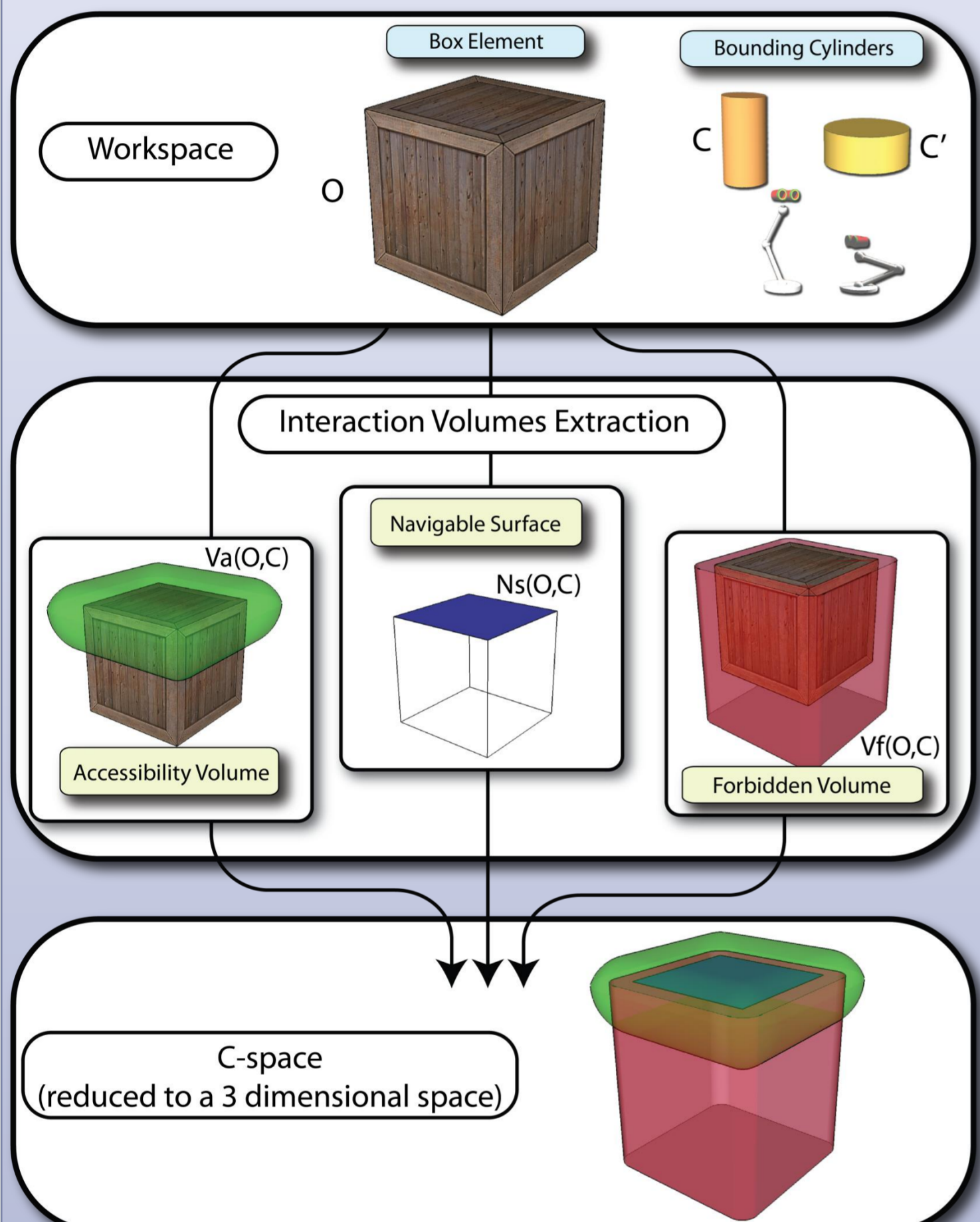
#### Contribution

- New representation of movable/moving objects in the C-Space.
- Representation allowing autonomous entities to navigate in changing environments by :
  - using different navigation capabilities
  - considering objects as obstacles and as navigable areas

### ToD & DyP

#### Interaction Volumes

Characterizing the C-space resulting from an interaction between an object and a given entity.

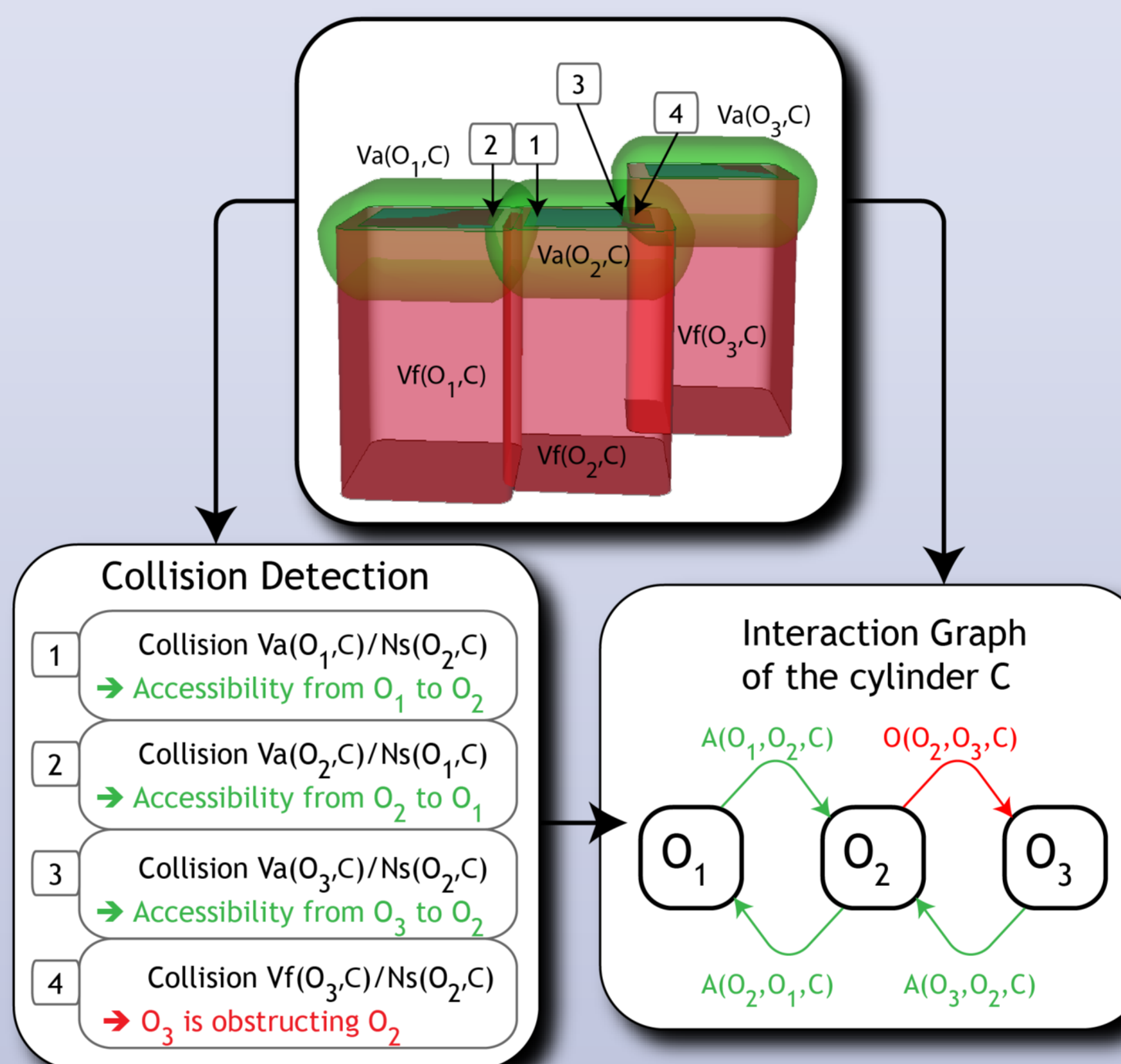


⇒ Interaction Volumes characterize subsets of feasible and colliding configurations in the C-Space

#### ToD : Topology Detection

Detect accessibilities and obstructions relations between objects

⇒ Computed by detecting collisions / intersections between *Interaction Volumes*



⇒ Characterization achieved by using collision detection between *Interaction Volumes* in the C-Space

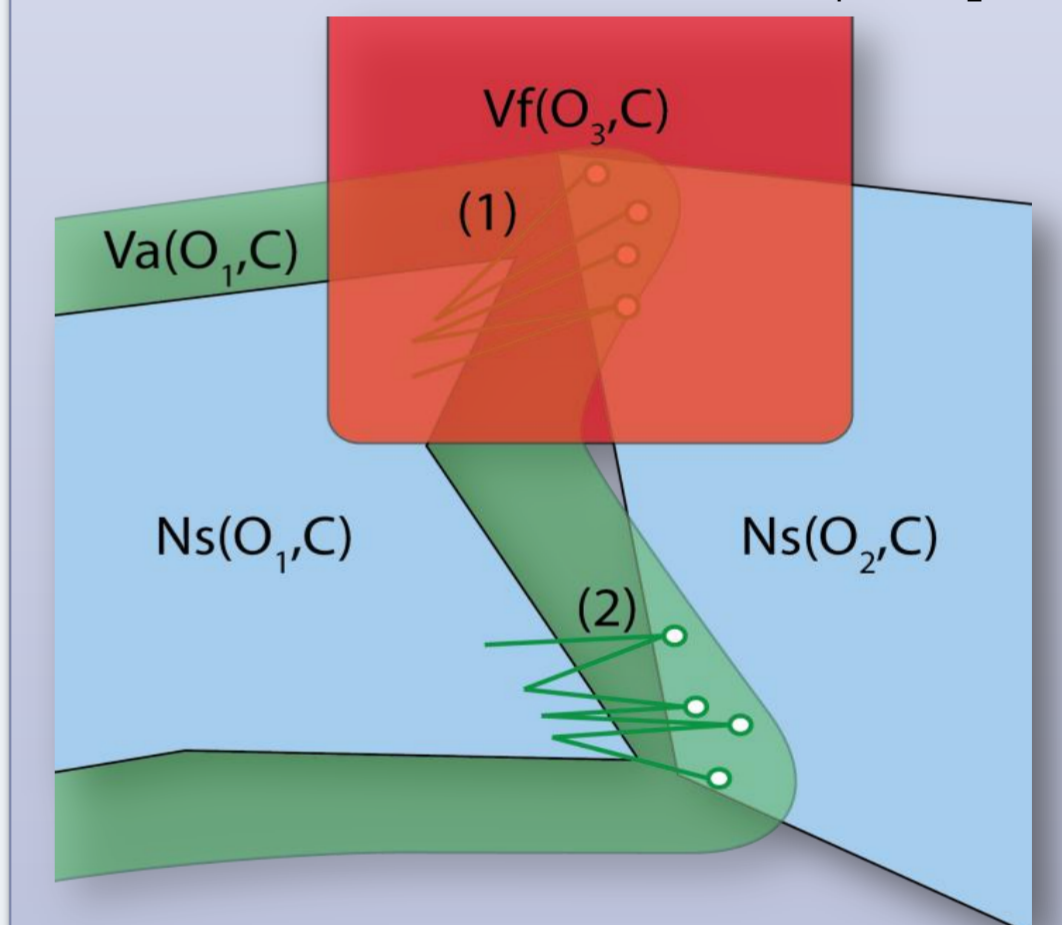
⇒ *Interaction Graph* : coarse and anytime representation of the workspace's topology, i.e., accessibility and obstruction

#### DyP : Dynamic Planner

Compute paths through movable objects

- Local roadmap associated to each object
- Two-step process :
  - Interconnection of local roadmaps ⇒ *Accessibility* between objects
  - Filtering of local roadmaps ⇒ *Obstruction* due to obstacles
- ⇒ Driven by the Interaction Graph and the Interaction Volumes

Example : Computation of the connection points for the accessibility from  $O_1$  to  $O_2$



- Two-level path planner:
  - Identification of Navigable Areas that must be crossed
  - Local Path Planning on each identified Areas

### Results & Conclusion

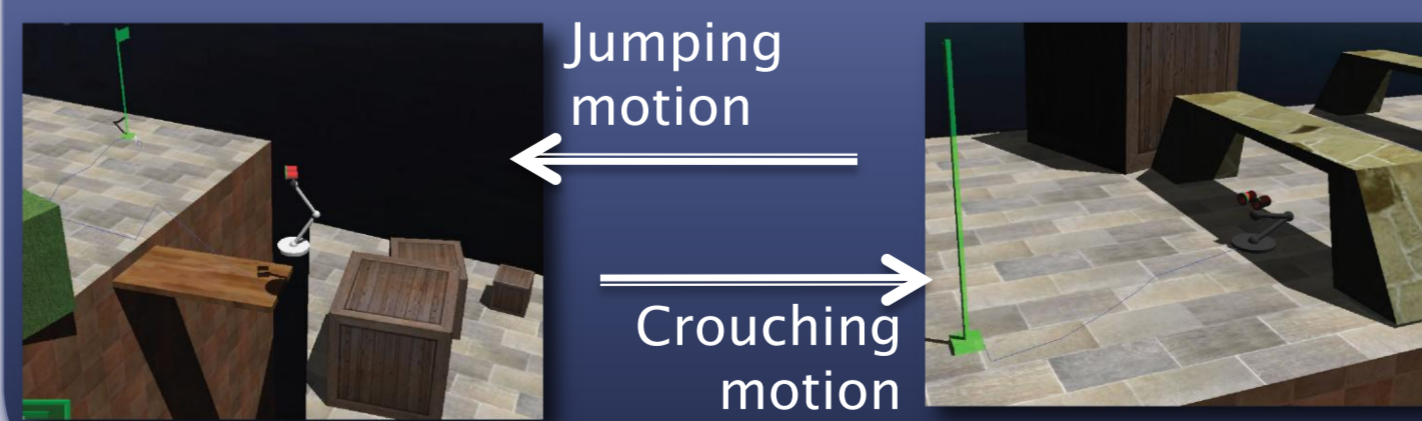
- ToD & DyP address a **new and complex path planning problem** in changing environments:
  - Elements of the workspace → **obstacles and navigable areas** during the navigation task
  - Navigation capabilities of the entity → **characterize colliding and feasible configurations** in the C-space
- ToD & DyP tracks modification in the topology at any time and dynamically adapt both computed paths and character's postures

The entity is able to find its path while:

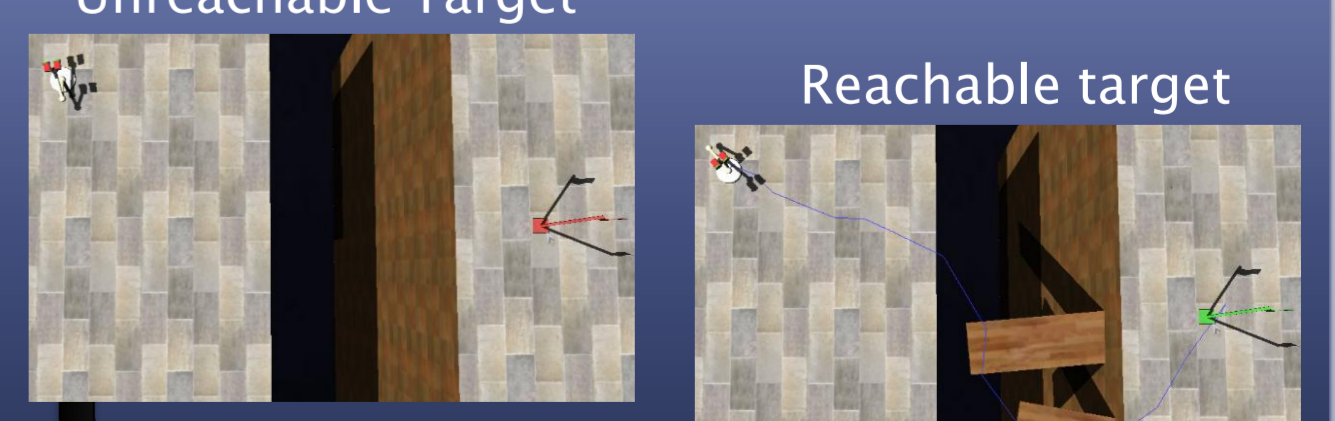
- Avoiding obstructed areas
- Navigating through disconnected navigable surfaces



Using different capabilities the entity is able to accurately navigate in a changing and disconnected environment.



On-the-fly detection of topological changes



Dynamic addition of planks to create a stair