Multi-object Transportation using a Mobile Robot

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Object Manipulation

Transport and manipulation of objects is a basic task in other actions:

Transport

Construction

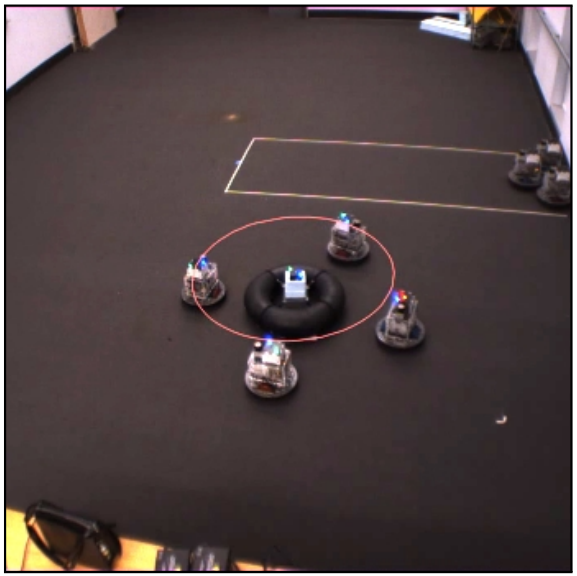
Tools

Household Usage

Types of manipulation

Prehensile

Agent uses a manipulator to hold the object to be transported.



[Fink et al., 2008]

Non-prehensile

Agent uses action like trowing, rolling or pushing to transport the object.

[Kim et al., 2013]

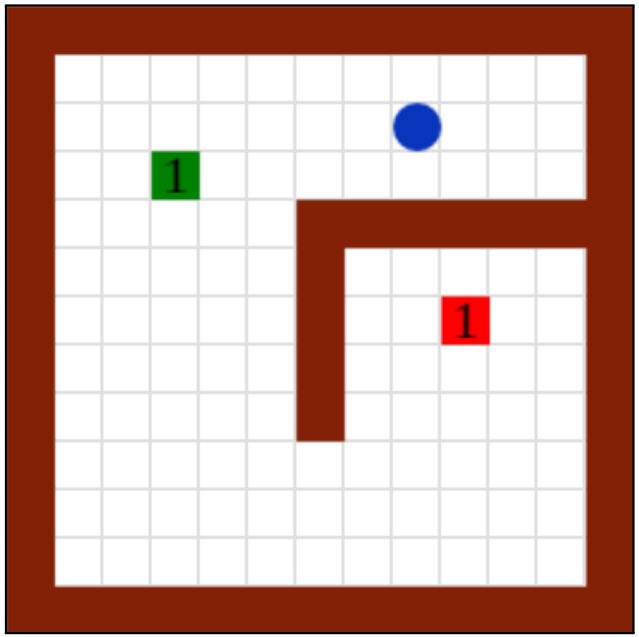
Related Works

- Inoue, Reiko, et al. "Rearrangement of multiple objects by a robot group having a multi-task function." International Conference on Robotics and Biomimetics 2009.
- Behrens, Michael, et al. "Models for pushing objects with a mobile robot using single point contact." International Conference on Intelligent Robots and Systems (IROS) 2010.
- Shiroma, Pedro M., and Mario FM Campos. "CoMutaR: A framework for multi-robot coordination and task allocation." International Conference on Intelligent Robots and Systems (IROS) 2009.

Problem Definition

Workspace know and discrete, with the following groups:

- Objects to be transported;
- Obstacles, blocking objects;
- Agent.

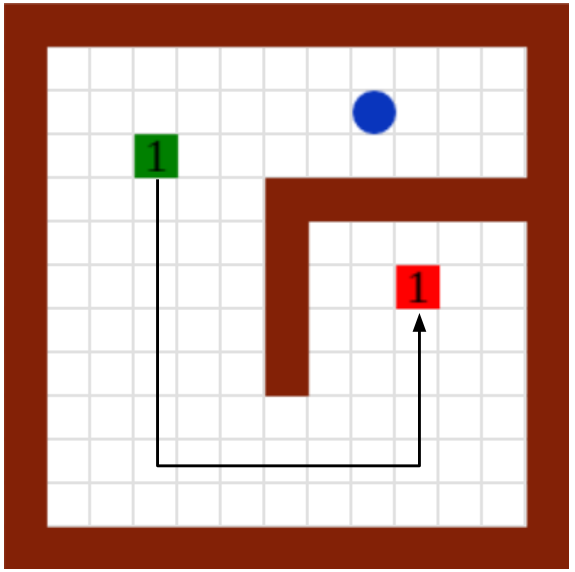


Workspace

Problem Definition

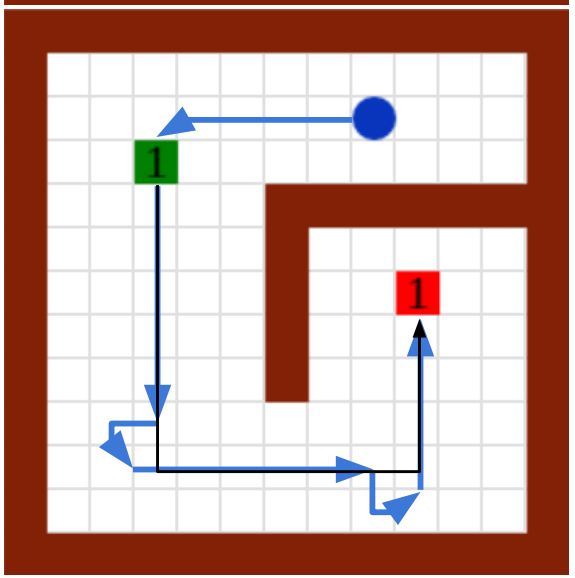
Problem 1 *Object Path Planning*

Find a feasible path inside the workspace to each object, starting from its initial position until a desired end position.



Problem 2 *Task Allocation and Execution*

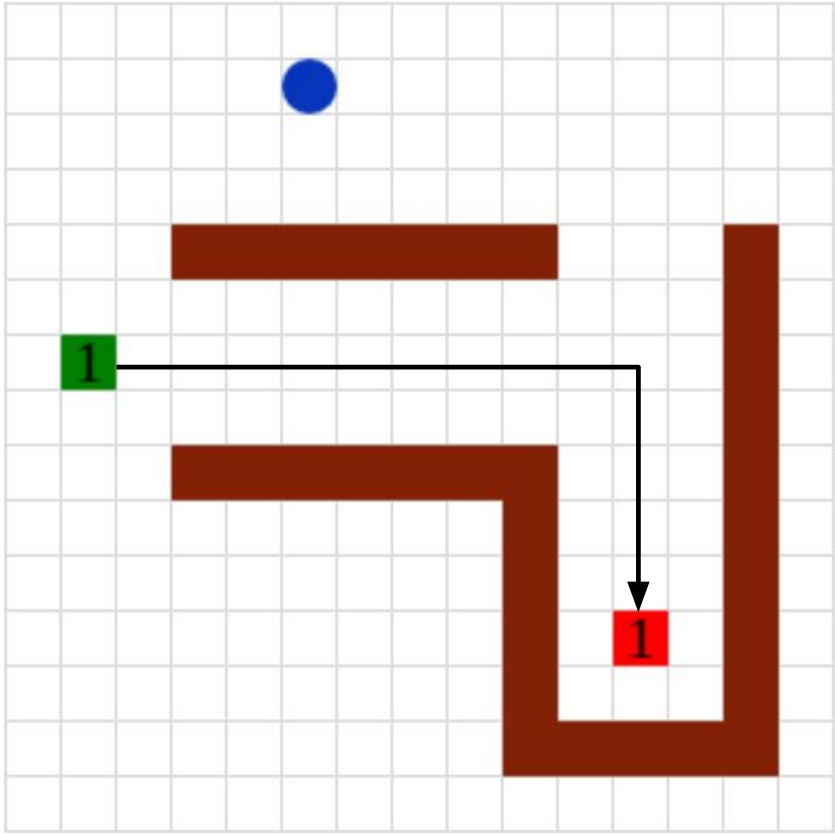
Control the agent to create a set of plans to accomplish all tasks, trying to minimize the total traveled distance.



Path Planning - Object

Planning for a object from set $\mathcal{O}$ has two phases:

1. *Planning*: a travel plan is created;
2. *Segmentation*: the plan is splitted into sub-plans.



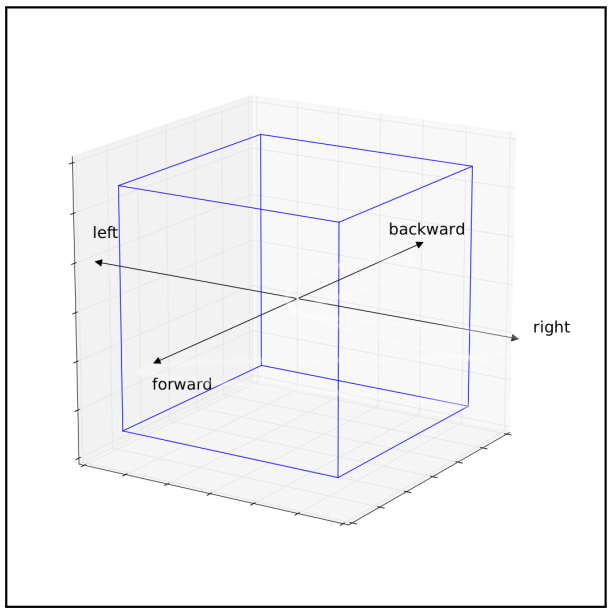
Object Plan

Path Planning - Object

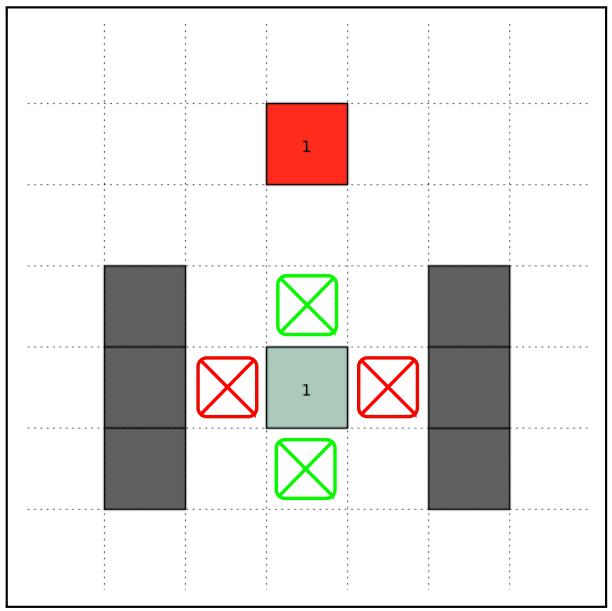
Planning Algorithm

Description

- Based on A* Algorithm;
- Using as Heuristic the remainder distance to the goal.



Available movements.



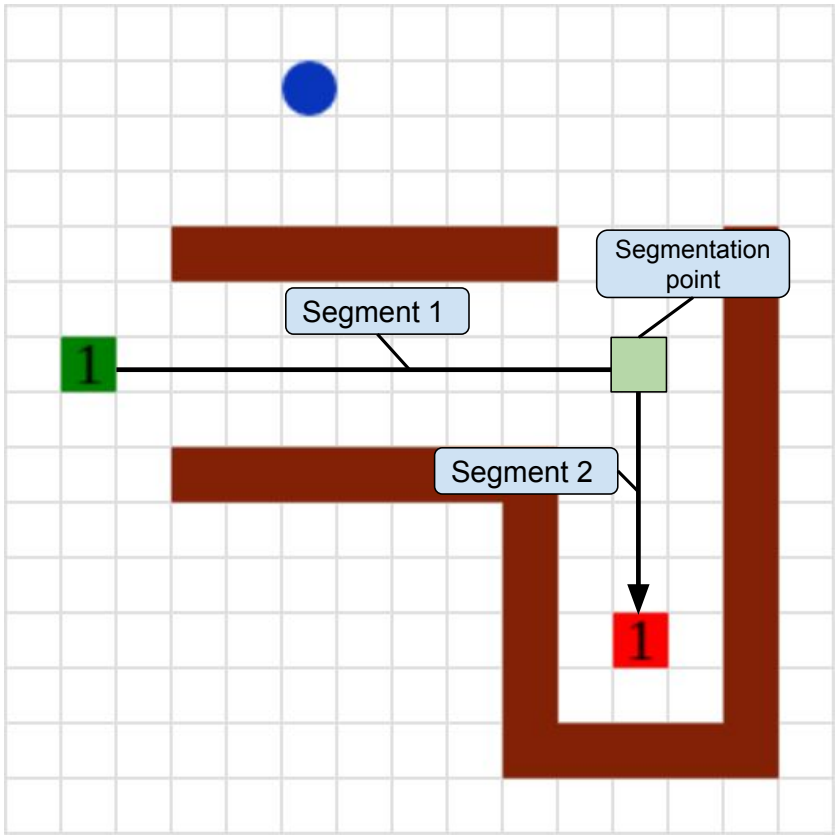
Collision test.

Path Planning - Object

Segmentation Algorithm

Segmentation occurs in two steps:

1. Creation of segmentation points;
2. Plan segmentation.

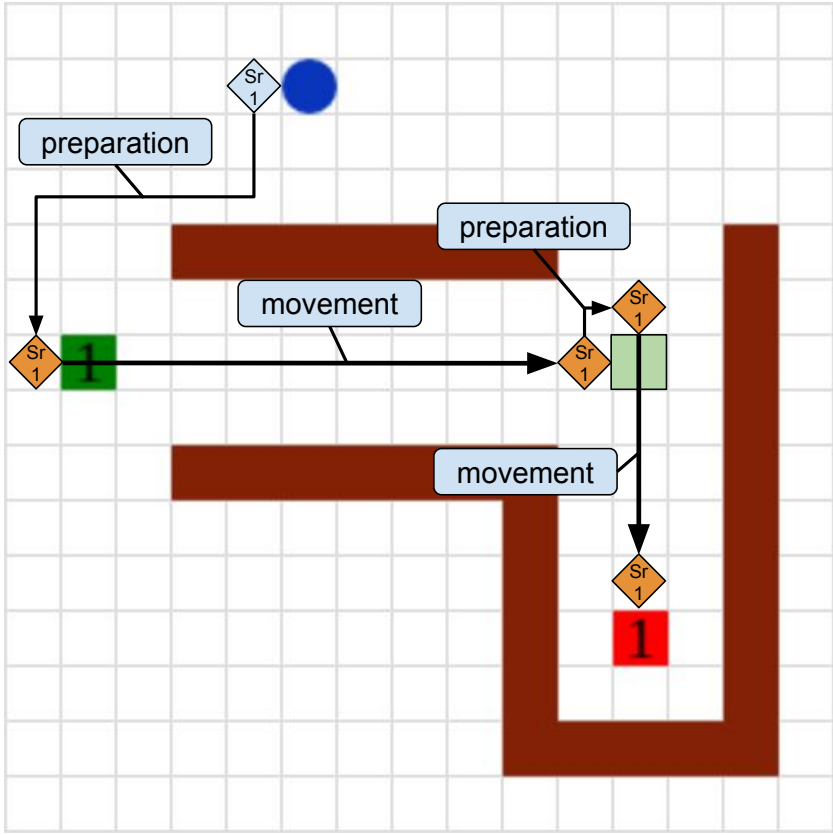


Object Plan segmented

Path Planning - Agents

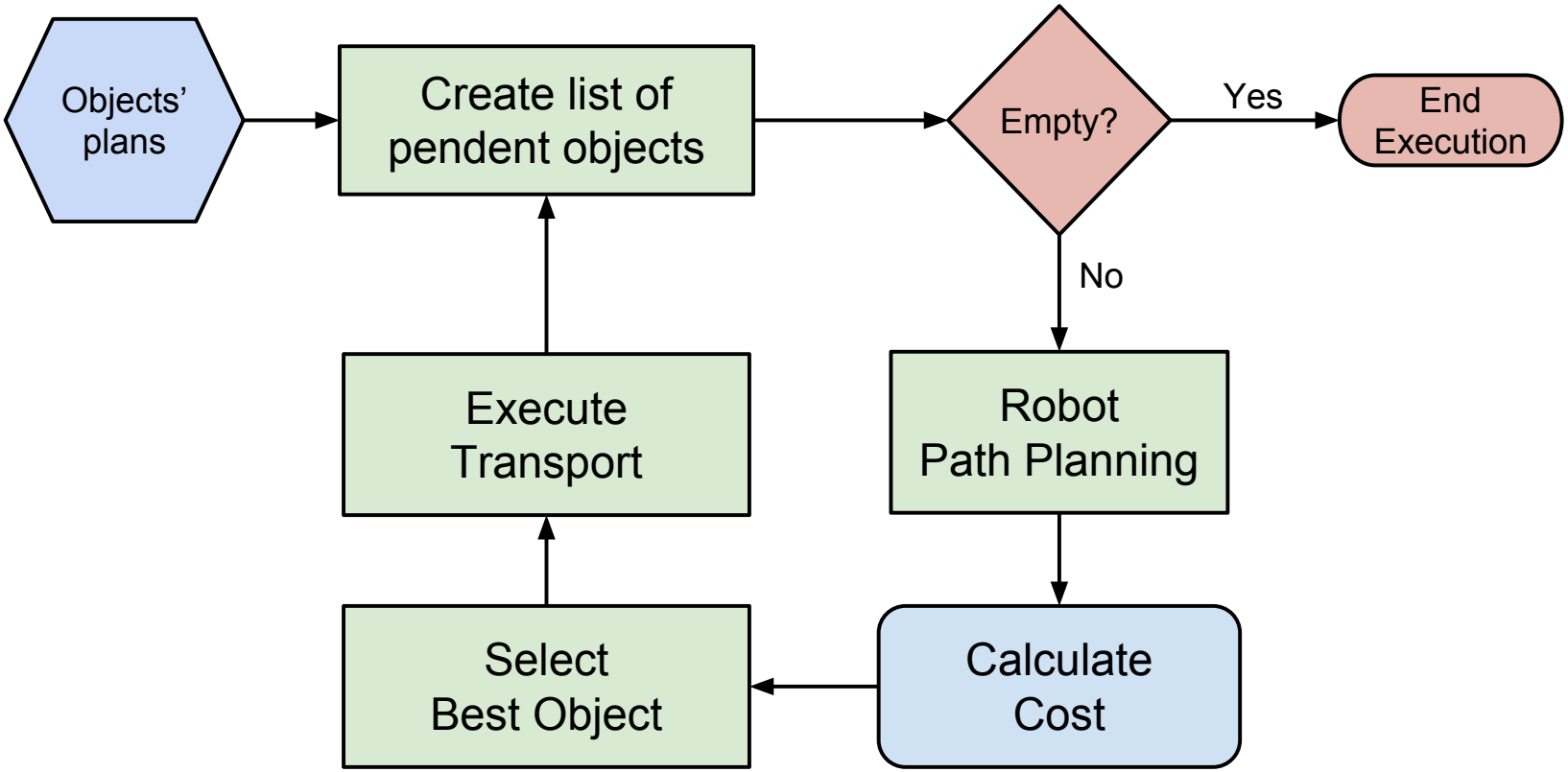
Based on segments created from the object's plan, movimentation plans are created, of two types:

- *Preparation*: plan in which the robot approaches the object to be transported;
- *Transport*: plan used to transport the object.



Agent's Plan

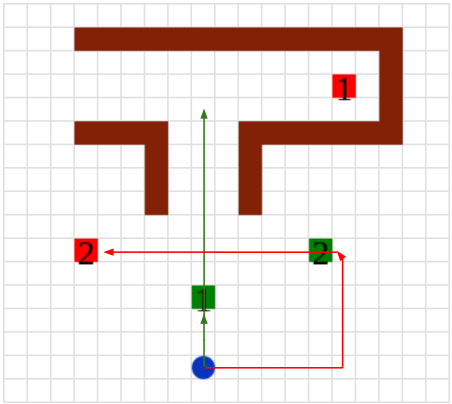
Task Allocation



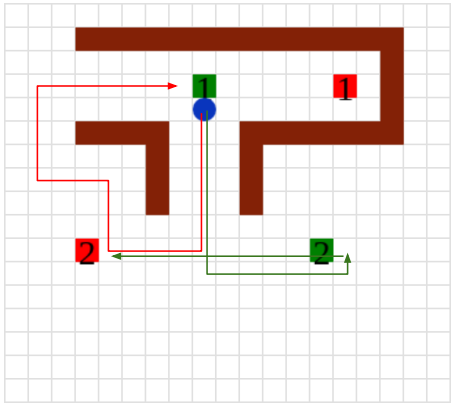
Task Allocation Process

Task Allocation

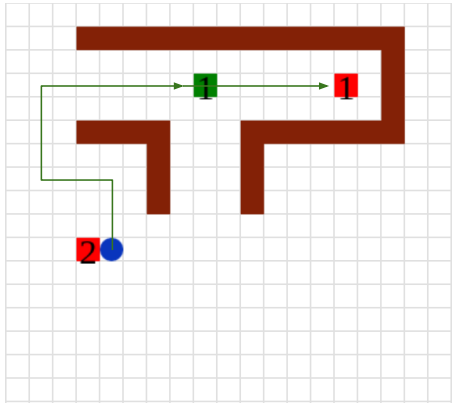
Execution Example



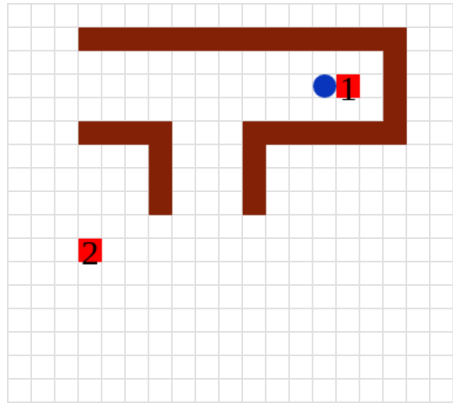
Select Object 1



Select Object 2



Select Object 1



Completed

Experiments

Description

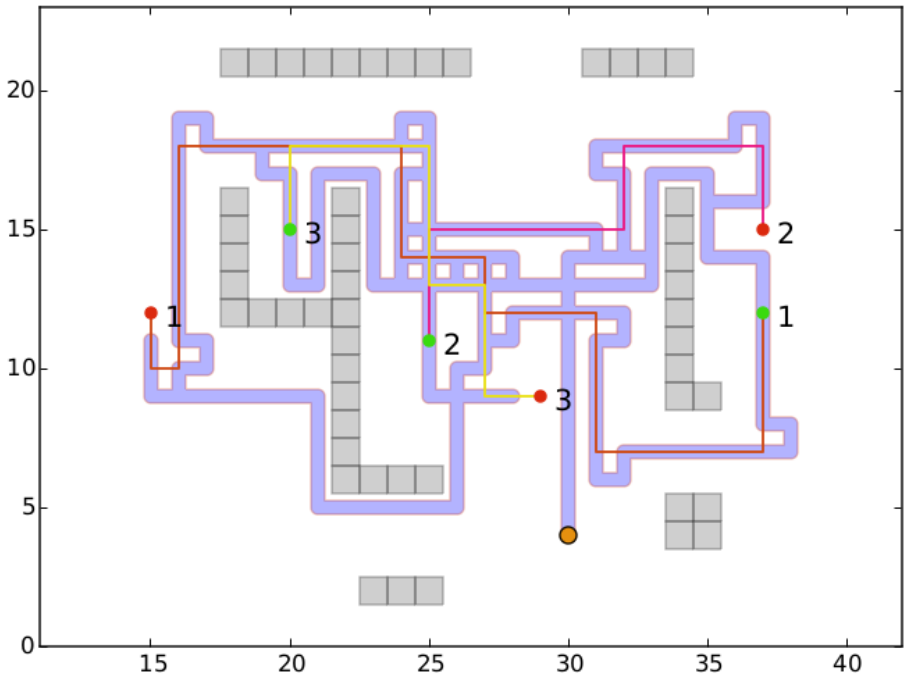
The proposed methodology was compared with a simple transportation method, in which transport of objects is made in a sequential manner.

Several tests were conducted to examine the methods behavior, considering two types:

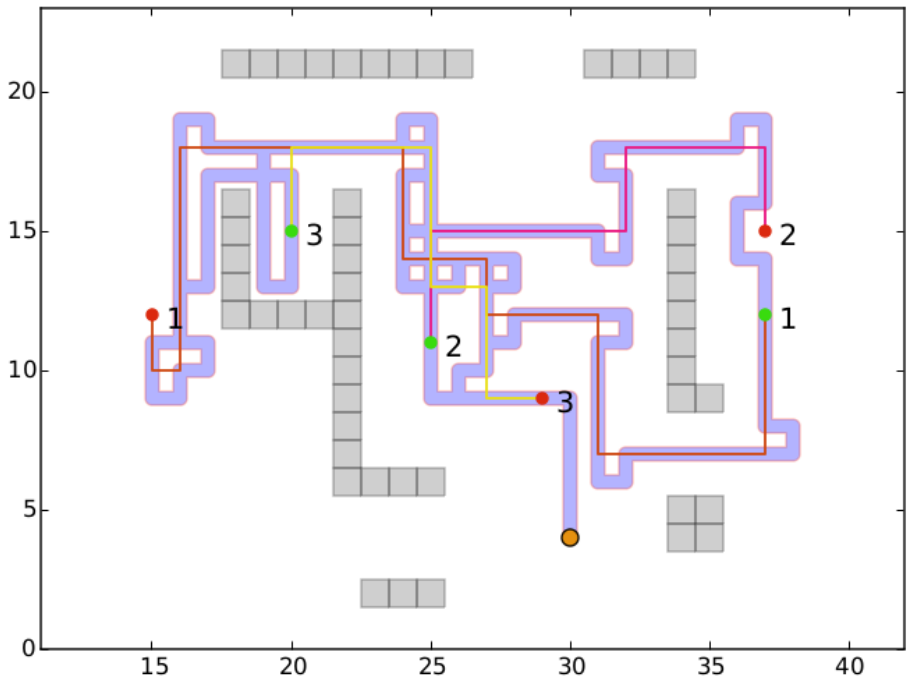
1. Total time of planning and task allocation phases;
2. Sum of total traveled space in unit cells by the agent;

Experiments

Illustrative Comparison



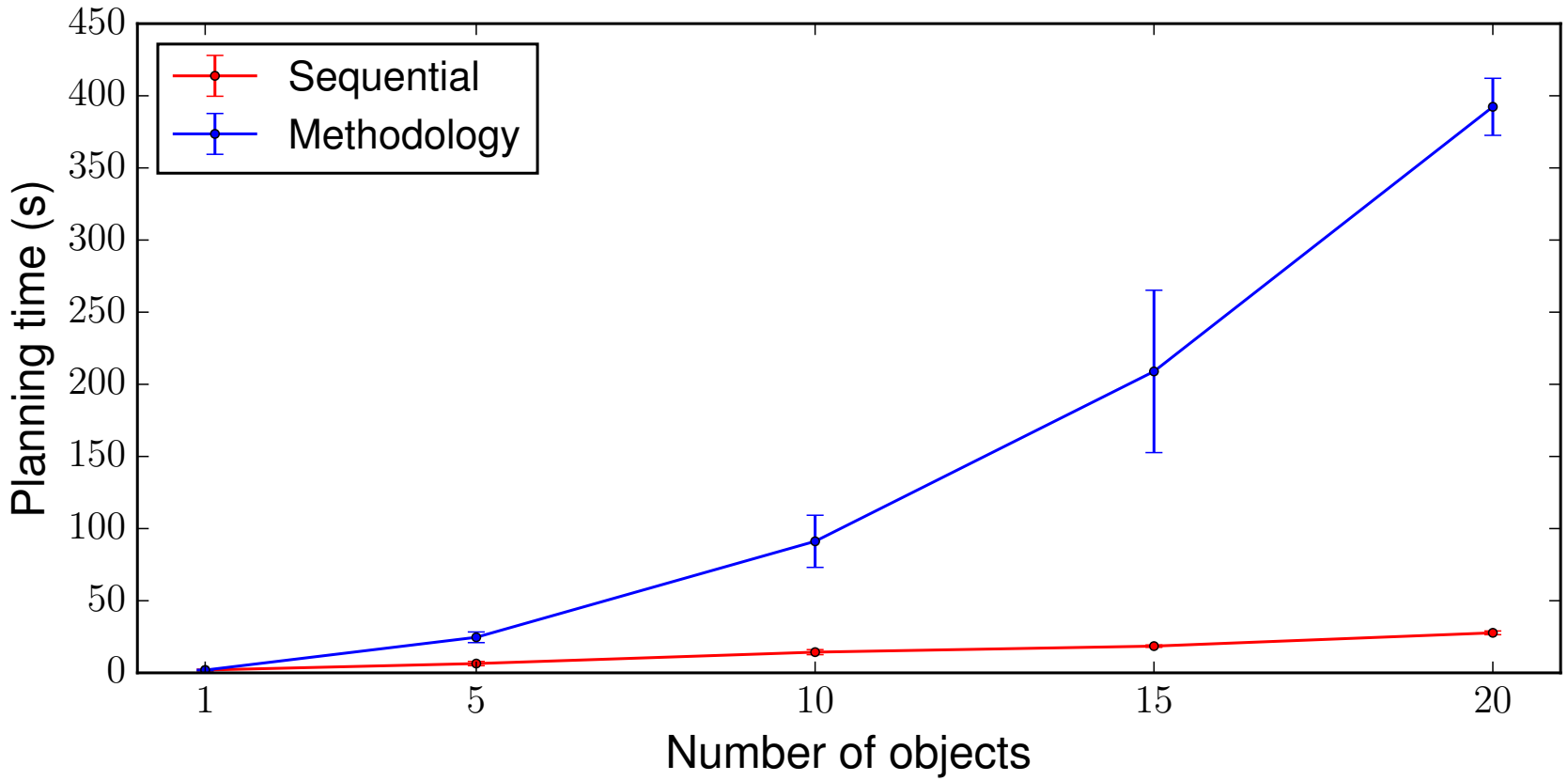
Sequential Method



Proposed Method

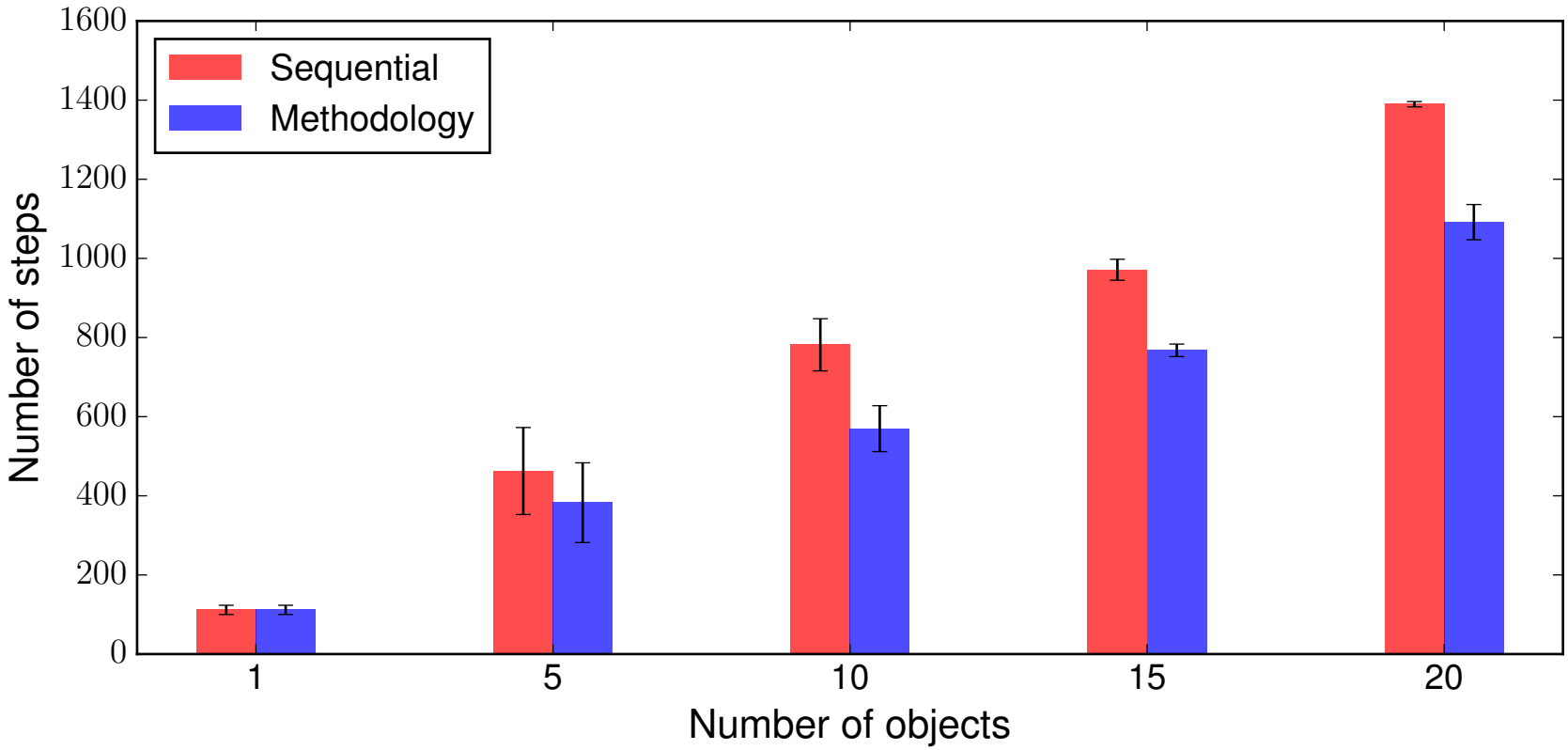
Experiments

Planning Time



Experiments

Traveled Distance



Conclusion

This work proposes a methodology to efficiently execute the transportation of multiple objects in a environment with obstacles considering the use of a single robot.

The technique is capable of treat all aspects of the problem, starting from the path planning, task allocation and execution of the task.

The experiments showed the effectiveness of the method, presenting a improvement in relation to the total traveled distance by the robot when compared to a simple sequential method.

Future directions include the extension of the proposed process to consider a cooperative transport with multiple agents.

References I

Fink, J., Ani Hsieh, M., and Kumar, V. (2008).

Multi-robot manipulation via caging in environments with obstacles.

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Kim, M.-H., Baik, H., and Lee, S. (2013).

Response threshold model based uav search planning and task allocation.

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