



Hochschule Bonn Rhein Sieg

Planning and Scheduling

Project: Storing Groceries

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Project overview

The robot has to store groceries placed on a table in a nearby cupboard. The cupboard has three shelves and a door which is closed at the beginning. The robot has one gripper which is empty at the beginning.

Planner : pyhop

- Pyhop - A Hierarchical Task Network Planner.
- Language - python (2.7 and 3.2)
- Developed by - Dana S. Nau.
- State - python object
- HTN operators and methods - Python functions.



Operators:

goto(r,x,y): robot goes from x to y

- Precond: robot is at x
- Effects: robot is at y

open(r,x): robot opens cupboard door

- Precond: robot is at x, hand empty
- Effect: x is open

perceiveObjects(r,y): robot perceives objects on table.

pick(r,o,x): robot picks o from x

- Precond: handempty, robot at x, o is at x
- Effect: pick o from x, holding object x, object $o \rightarrow$ on place x

place(r,o,y): robot places o in x

- Precoand: holding object o , robot is at x
- Effect: object o is on y

look_table(r): robot locates table

look_cupboard(r): robot located cupboard



Methods:

Case1:

- **Task1:** Place objects from x on y
 - **Subtasks:** (open,r, x), (goto,r, x, y), (pick,r,o,y), (goto,r, y, x), (place,r,o,x)

Case2:

- **Task1:** Place objects from x on y
 - **Subtasks:** (look_cupboard,r), (goto, r, ' ',x), (open, r, x), (look_table, r), (goto, r, x, y), (pick, r, o, y), (goto, r, y, x), (place, r, o, x), (goto, r, x, y)



Methods:

Case3:

- **Task1:** Place objects from x on y
 - **Subtasks:** (look_cupboard,r), (goto, r, ' ',x), (open, r, x), (look_table, r), (goto, r, x, y), (perceiveObjects,y), (pick, r,o,y), (goto, r, y, x), (place, r, o, x), (goto, r, x, y)

Case4:

- **Task1:** Place objects from x on y
 - **Subtasks:** (look_cupboard,r), (goto, r, ' ',x), (open,r, x), (look_table,r), (goto,r, x, y), (perceiveObjects, y), (pick,r, o, y), (goto,r, y, x), (place,r,o,x), (goto,r, x, y)



Case 1:

Initial state:

- An object placed on table.
- Location of table and cupboard is known
- Cupboard door is closed.

Final State:

- The object is placed in cupboard

Assumptions:

- Robot is initially at cupboard
- The cupboard door is opened by the robot and this is maintained until the task is completed.
- Robot gripper can perform pick and place of objects, and opening cupboard door.

Case 1:

Pick and place objects(r, x, y)

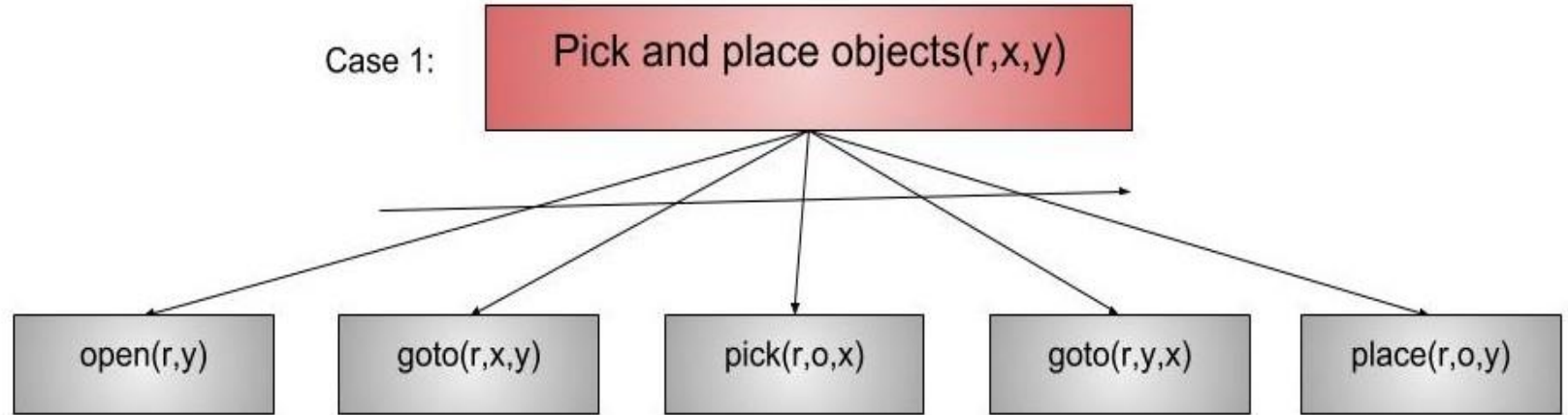
open(r, y)

goto(r, x, y)

pick(r, o, x)

goto(r, y, x)

place(r, o, y)





Case 2:

Initial state:

- There are ' n ' objects on the table. The objects and its location on the table is known
- Locations of robot, table and cupboard is unknown
- The cupboard door is closed

Final state:

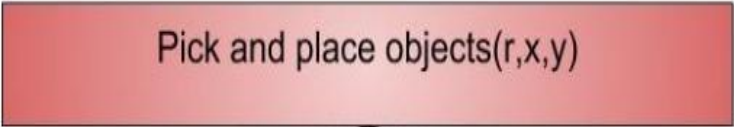
Objects are placed on the cupboard shelves

Assumptions:

- Locations of the table and cupboard is perceived once. This information is exploited whenever needed
- The cupboard door is opened by the robot and this is maintained until the task is completed.
- Robot gripper can perform pick and place of objects, and opening cupboard door.



Case 2:





Case 3:

Initial State:

- 'n' objects are placed on table
- Objects are unknown
- Location of table, cupboard and robot are unknown
- Cupboard door is closed

Final State:

- Objects are in cupboard

Assumptions:

- Perception module is executed once and information is exploited whenever needed.
- Robot gripper can perform pick and place of objects, and opening cupboard door.
- The cupboard door is opened by the robot and this is maintained until the task is completed.

Case 3:

Pick and place objects(r,x,y)





Case 4:

Initial State:

- 'n' objects are placed on table
- Objects are unknown
- Location of table, cupboard and robot are unknown
- Cupboard door is closed

Final State:

- Objects are categorized and are placed in cupboard

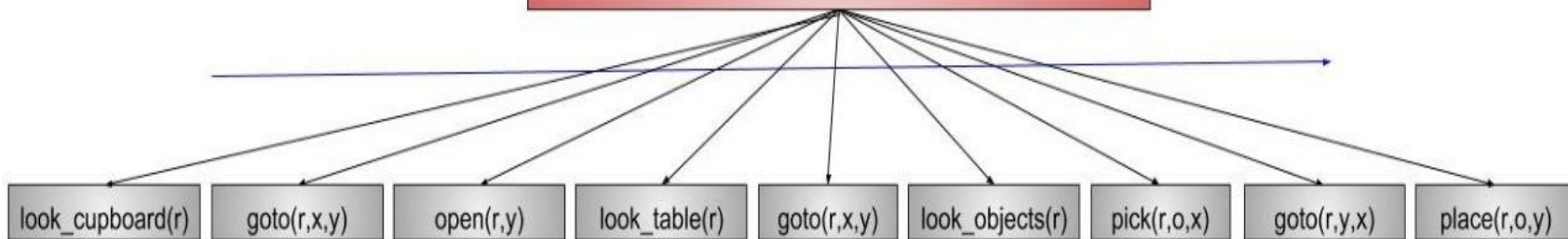
Assumptions:

- Perception module is executed once and information is exploited whenever needed.
- Robot gripper can perform pick and place of objects, and opening cupboard door.
- The cupboard door is opened by the robot and this is maintained until the task is completed



Case 4:

Pick and place objects(r,x,y)





Failure Cases

- Objects on table - 0. The operator '***pick***' fails to execute (Case2).
- ***Goto*** operator is specific to locations 'cupboard' and 'table'.
- Failed to generalize ***perception*** module



Thank you :)