TY CSE AY-2022-23 Sem-I

Artificial Intelligence and Machine Learning Lab

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Ass-4
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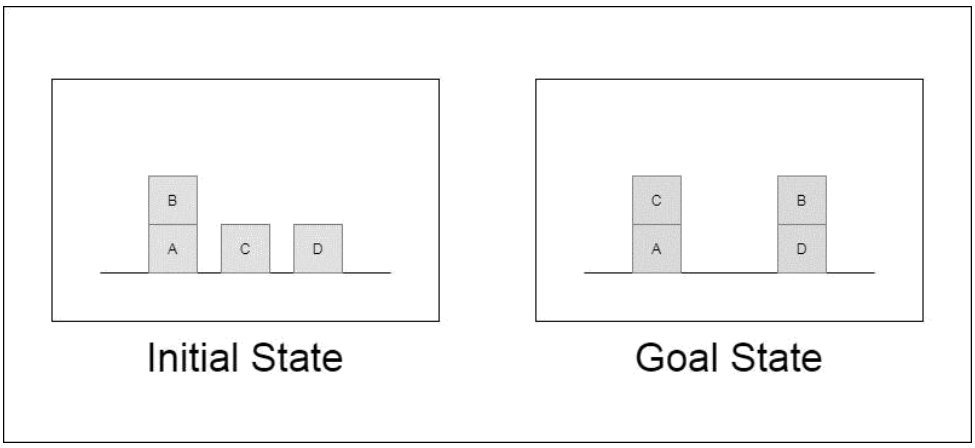
1. Consider the Blocks World Problem given below. Using Goal Stack Planning
    a. Elaborate the operations required to achieve goal state.
    b. Implement the problem using python to achieve goal.



a.

We work backwards from the goal, looking for an operator which has one or more of the goal literals as one of its effects and then trying to satisfy the preconditions of the operator. - The preconditions of the operator become subgoals that must be satisfied.We keep doing this unti lwe reach the initial state. Goal stack planning uses a stack to hold goals and actions to satisfy the goals, and a knowledge base to hold the current state,action schemas and domain axioms - Goal stack is like a node in a search tree; if there is a choice of action,we create branches

Goal stack planning pseudocode :

Push the original goal on the stack.Repeat until the stack is empty: - If stack top is a compound goal, push its unsatisfied subgoals on the stack. - If stack top is a single unsatisfied goal,replace it by an action that makes it satisfied and push the action’s precondition on the stack. - If stack top is an action, pop it from the stack, execute it and change the knowledge base by the action’s effects. - If stack top is a satisfied goal, pop it from the stack.

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Q.1

Ans: (i) Initial state:

ON (B, A) ∧ ONTABLE (A) ∧ ONTABLE (C) ∧ ONTABLE (D)
∧ CLEAR (B) ∧ CLEAR (C) ∧ CLEAR (D) ∧ ARMEMPTY

(ii) Goal state:

ON (C, A) ∧ ON (B, D) ∧ ONTABLE (A) ∧ ONTABLE (D) ∧
CLEAR (B) ∧ CLEAR (C) ∧ ARMEMPTY

(iii) Steps:

	operation	precondition	Action
1	UNSTACK (B, A)	(1) ARMEMPTY (2) ON (B, A) (3) CLEAR (B)	(1) Holding (B) (2) Clear (A)
2	STACK (B, D)	(1) CLEAR (D) (2) Holding (B)	(1) ARMEMPTY (2) ON (B, D)
3	PICKUP (C)	(1) CLEAR (C) (2) ONTABLE (C) (3) ARMEMPTY	(1) HOLDING (C)
4	STACK (C, A)	(1) CLEAR (A) (2) HOLDING (C)	(1) ARMEMPTY (2) ON (C, A)

```
#Base Classes

#PREDICATE - ON, ONTABLE, CLEAR, HOLDING, ARMEMPTY
class PREDICATE:
  def __str__(self):
    pass
  def __repr__(self):
    pass
  def __eq__(self, other) :
    pass
```

```
  def __hash__ self
    pass
  def get_action(self, world_state):
    pass


#OPERATIONS - Stack, Unstack, Pickup, Putdown
class Operation:
  def __str__(self):
    pass
  def __repr__(self):
    pass
  def __eq__(self, other) :
    pass
  def precondition(self):
    pass
  def delete(self):
    pass
  def add(self):
    pass


class ON(PREDICATE):

  def __init__(self, X, Y):
    self.X = X
    self.Y = Y

  def __str__(self):
    return "ON({X},{Y})".format(X=self.X,Y=self.Y)

  def __repr__(self):
    return self.__str__()

  def __eq__(self, other) :
    return self.__dict__ == other.__dict__ and self.__class__
== other.__class__
```

```
  def __hash__(self):
      return hash(str(self))

  def get_action(self, world_state):
    return StackOp(self.X,self.Y)


class ONTABLE(PREDICATE):

  def __init__(self, X):
    self.X = X

  def __str__(self):
    return "ONTABLE({X})".format(X=self.X)

  def __repr__(self):
    return self.__str__()

  def __eq__(self, other) :
    return self.__dict__ == other.__dict__ and self.__class__
== other.__class__

  def __hash__(self):
      return hash(str(self))

  def get_action(self, world_state):
    return PutdownOp(self.X)


class CLEAR(PREDICATE):

  def __init__(self, X):
    self.X = X

  def __str__(self):
    return "CLEAR({X})".format(X=self.X)
    self.X = X

  def __repr__(self):
    return self.__str__()

  def __eq__(self, other) :
    return self.__dict__ == other.__dict__ and self.__class__
== other.__class__

  def __hash__(self):
    return hash(str(self))

  def get_action(self, world_state):
    for predicate in world_state:
```

```
      #If Block is on another block, unstack
      if isinstance(predicate,ON) and predicate.Y==self.X:
        return UnstackOp(predicate.X, predicate.Y)
    return None


class HOLDING(PREDICATE):

  def __init__(self, X):
    self.X = X

  def __str__(self):
    return "HOLDING({X})".format(X=self.X)

  def __repr__(self):
    return self.__str__()

  def __eq__(self, other) :
    return self.__dict__ == other.__dict__ and self.__class__
== other.__class__

  def __hash__(self):
    return hash(str(self))

  def get_action(self, world_state):
    X = self.X
    #If block is on table, pick up
    if ONTABLE(X) in world_state:
      return PickupOp(X)
    #If block is on another block, unstack
    else:
      for predicate in world_state:
        if isinstance(predicate,ON) and predicate.X==X:
          return UnstackOp(X,predicate.Y)


class ARMEMPTY(PREDICATE):

  def __init__(self):
    pass

  def __str__(self):
    return "ARMEMPTY"

  def __repr__(self):
    return self.__str__()

  def __eq__(self, other) :
    return self.__dict__ == other.__dict__ and self.__class__
== other.__class__
```

```
  def __hash__(self):
    return hash(str(self))

  def get_action(self, world_state=[]):
    for predicate in world_state:
      if isinstance(predicate,HOLDING):
        return PutdownOp(predicate.X)
    return None


class StackOp(Operation):

  def __init__(self, X, Y):
    self.X = X
    self.Y = Y

  def __str__(self):
    return "STACK({X},{Y})".format(X=self.X,Y=self.Y)

  def __repr__(self):
    return self.__str__()

  def __eq__(self, other) :
    return self.__dict__ == other.__dict__ and self.__class__
== other.__class__

  def precondition(self):
    return [ CLEAR(self.Y) , HOLDING(self.X) ]

  def delete(self):
    return [ CLEAR(self.Y) , HOLDING(self.X) ]

  def add(self):
    return [ ARMEMPTY() , ON(self.X,self.Y) ]


class UnstackOp(Operation):

  def __init__(self, X, Y):
    self.X = X
    self.Y = Y

  def __str__(self):
    return "UNSTACK({X},{Y})".format(X=self.X,Y=self.Y)

  def __repr__(self):
    return self.__str__()

  def __eq__(self, other) :
```

```
    return self.__dict__ == other.__dict__ and self.__class__
== other.__class__

  def precondition(self):
    return [ ARMEMPTY() , ON(self.X,self.Y) , CLEAR(self.X) ]

  def delete(self):
    return [ ARMEMPTY() , ON(self.X,self.Y) ]

  def add(self):
    return [ CLEAR(self.Y) , HOLDING(self.X) ]


class PickupOp(Operation):

  def __init__(self, X):
    self.X = X

  def __str__(self):
    return "PICKUP({X})".format(X=self.X)

  def __repr__(self):
    return self.__str__()

  def __eq__(self, other) :
    return self.__dict__ == other.__dict__ and self.__class__
== other.__class__

  def precondition(self):
    return [ CLEAR(self.X) , ONTABLE(self.X) , ARMEMPTY() ]

  def delete(self):
    return [ ARMEMPTY() , ONTABLE(self.X) ]

  def add(self):
    return [ HOLDING(self.X) ]


class PutdownOp(Operation):

  def __init__(self, X):
    self.X = X

  def __str__(self):
    return "PUTDOWN({X})".format(X=self.X)

  def __repr__(self):
    return self.__str__()

  def __eq__(self, other) :
```

```
    return self.__dict__ == other.__dict__ and self.__class__
== other.__class__

  def precondition(self):
    return [ HOLDING(self.X) ]

  def delete(self):
    return [ HOLDING(self.X) ]

  def add(self):
    return [ ARMEMPTY() , ONTABLE(self.X) ]


def isPredicate(obj):
  predicates = [ON, ONTABLE, CLEAR, HOLDING,
  ARMEMPTY] for predicate in predicates:
    if isinstance(obj,predicate):
      return True
  return False

def isOperation(obj):
  operations = [StackOp, UnstackOp, PickupOp,
  PutdownOp] for operation in operations:
    if isinstance(obj,operation):
      return True
  return False

def arm_status(world_state):
  for predicate in world_state:
    if isinstance(predicate, HOLDING):
      return predicate
  return ARMEMPTY()


class GoalStackPlanner:

  def __init__(self, initial_state,
    goal_state): self.initial_state =
    initial_state self.goal_state = goal_state

  def get_steps(self):

    #Store Steps
    steps = []

    #Program Stack
    stack = []

    #World State/Knowledge Base
    world_state = self.initial_state.copy()
```

```
    #Initially push the goal_state as compound goal onto the stack
    stack.append(self.goal_state.copy())

    #Repeat until the stack is empty
    while len(stack)!=0:

      #Get the top of the stack
      stack_top = stack[-1]

      #If Stack Top is Compound Goal, push its unsatisfied goals onto
      stack if type(stack_top) is list:
        compound_goal = stack.pop()
        for goal in compound_goal:
          if goal not in world_state:
            stack.append(goal)

      #If Stack Top is an action
      elif isOperation(stack_top):

        #Peek the operation
        operation = stack[-1]

        all_preconditions_satisfied = True

        #Check if any precondition is unsatisfied and push it onto program
stack
        for predicate in operation.delete():
          if predicate not in world_state:
            all_preconditions_satisfied = False
            stack.append(predicate)

        #If all preconditions are satisfied, pop operation from stack
and execute it
        if all_preconditions_satisfied:

          stack.pop()
          steps.append(operation)

          for predicate in operation.delete():
            world_state.remove(predicate)
          for predicate in operation.add():
            world_state.append(predicate)


      #If Stack Top is a single satisfied goal
      elif stack_top in world_state:
        stack.pop()
```

```
      #If Stack Top is a single unsatisfied
      goal else:
        unsatisfied_goal = stack.pop()

        #Replace Unsatisfied Goal with an action that can complete
        it action = unsatisfied_goal.get_action(world_state)

        stack.append(action)
        #Push Precondition on the stack
        for predicate in action.precondition():
          if predicate not in world_state:
            stack.append(predicate)

    return steps

if __name__ == '__main__':
  initial_state = [
    ON('B','A'),
    ONTABLE('A'),ONTABLE('C'),ONTABLE('D'),
    CLEAR('B'),CLEAR('C'),CLEAR('D'),
    ARMEMPTY()
  ]

  goal_state = [
    ON('B','D'),ON('C','A'),
    ONTABLE('D'),ONTABLE('A'),
    CLEAR('B'),CLEAR('C'),
    ARMEMPTY()
  ]

  goal_stack = GoalStackPlanner(initial_state=initial_state,
goal_state=goal_state)
  steps = goal_stack.get_steps()
  print(steps)
```

2. Having to plan a trip, say from Chennai to Jaipur, the first thing one might to do is to find suitable train and/or flight combinations between the two cities, and then fill in all the other actions. What kind of planning will allow one to do so?

3.

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Q.2. Start w initial state: Chennai
Goal state : Jaipur