Constraint Satisfaction

*Finding a solution that meets a set of constraints is the goal of constraint satisfaction problems (CSPs), a type of AI issue.

*Finding values for a group of variables that fulfill a set of restrictions or rules is the aim of constraint satisfaction problems.

*3 basic components
(i) Variables
(ii) Domains
(iii) Constraints.

Constraint Satisfaction Problem Representation.

→Finite set of variables $V_1, V_2, V_3, \ldots V_n$.
→Non empty domain for every single variable $D_1, D_2, D_3, \ldots D_n$.
→Finite set of constraints $C_1, C_2, \ldots C_m$.
→Each constraint Ci restricts the possible values for variables.
eg: $V_1 \neq V_2$
→Each constraint C_i is a pair <Scope, relation> eg <(V_1, V_2), $V_1 \neq V_2$>.

→Scope – Set of variables that participate in constraint.
→Relation – list of valid variable value combinations.

CSP Algorithm.

Backtracking algorithm.
Forward checking algorithm.
Propagating constraints.

Implementation code for CSP.

Sudoku Problem.

Python 3.

```
csp = CSP(variables, Domains, constraints)
sol = csp.solve()
Solution = [[0 for i in range(9)]
    for i in range(9)]
for i,j in sol:
    Solution[i][j] = sol[i,j]
    print_Sudoku(solution)
```

Output.

```
534 | 678 | 192
672 | 195 | 348
198 | 342 | 567
---------------
859 | 761 | 423
426 | 853 | 971
713 | 924 | 856
---------------
961 | 537 | 284
287 | 419 | 635
345 | 286 | 719
```

Real world CSP.

- → Scheduling
- → Vehicle Routing
- → Assignment

- → Sudoku
- → Constraint based Image segmentation

CSP Benefits.

Conventional representation patterns
Generic Successor & goal functions
Standard heuristics (no domain-specific expertise).

Means Ends Analysis.

It is a problem solving technique used in AI for limiting search in AI programs.

It is a mixture of forward & backward search technique.

MEA Technique was first introduced in 1961 by Allen Newell & Herbert A. Simon in their problem solving computer program which was named as General Problem Solver (GPS)

MEA analysis process centered on the evaluation of the difference btw current State & goal state.

How MEA works.

(i) Evaluate the difference btw initial state & final state.

(ii) Select the various operators which can be applied for each difference.

(iii) Apply the operator at each difference which reduces the difference btw current State & goal state.

Algorithm. → current state → Goal state

Lets We take CURRENT & GOAL.

(i) Compare CURRENT to GOAL, if there are no differences btw both then return success & Exit.

(ii) Else, Select the most significant difference & reduce it by doing the following steps until the success or failure occurs.

a) Select a new operator O which is applicable for the current difference & if there is no such operator then signal failure.

b) Attempt to apply operator O to CURRENT. Make the description of 2 states.

1) O-start, O's preconditions are satisfied.

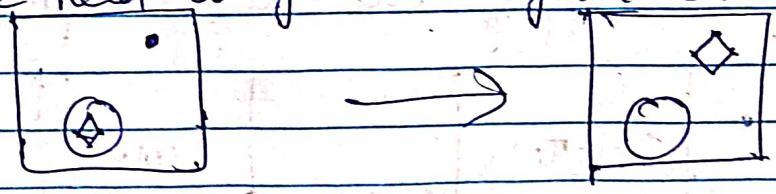
2) O-Result, if O were applied in O-start.

c) If (First-Part ← MEA (CURRENT, O-START) AND (LAST-Part ← MEA (O-Result, GOAL) are successful:

then sign success & return the result of combining FIRST-PART, O, LASTPART.

Example.

We need to get the goal state by finding



Initial state . Goal state.

diff. btw the initial state & goal state & applying operators.

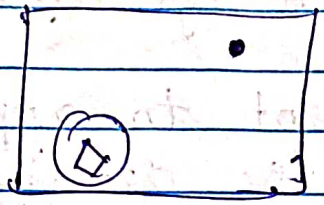
Solution.

Operators for this problem.

→ move
→ Delete
→ Expand

1. Evaluating the initial state.

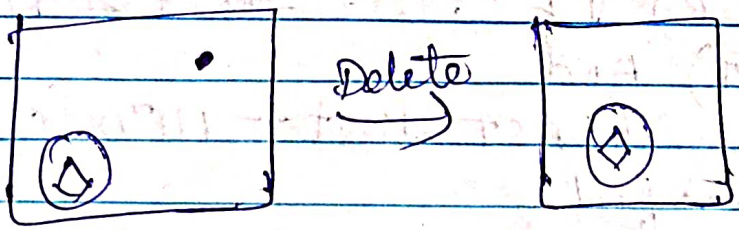
→ We will evaluate the initial state will compare the initial & goal state to find the differences btw both sides.



→ Initial state.

2. Applying delete operator.

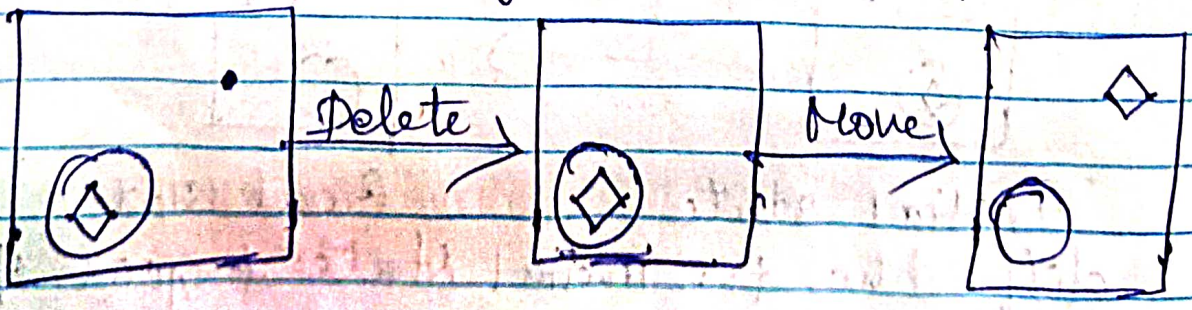
→ Remove the dot by using the delete operator.



3. Applying move operator.

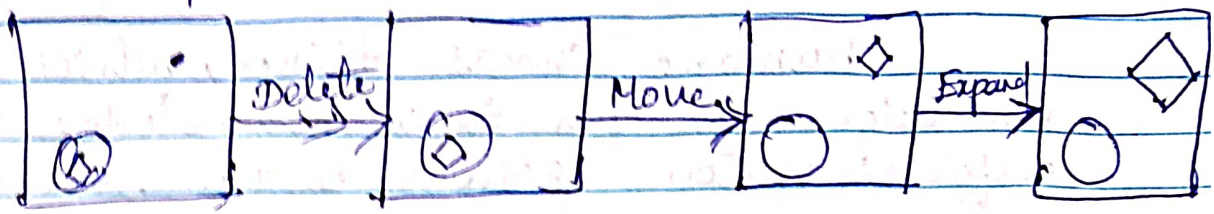
→ Compare the goal state.

→ The square is outside the circle. So we will apply the move operator.



1. Applying Expand Operator.

→ There is one difference which is the size of the Square. So we will apply the expand operator.



Initial state

Goal state