

PRACTICAL FILE
COURSE : ARTIFICIAL INTELLIGENCE
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B.TECH SEMESTER-V



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Experiment 1

Aim: Write a program to solve the 8-Puzzle problem using Generate and Test Strategy.

Code:

```
#include<bits/stdc++.h>
using namespace std;

int solve8Puzzle(vector<vector<int>> &grid){
    vector<vector<int>> dir={{1,3},{0,2,4},{1,5},{0,4,6},{1,3,5,7},{2,4,8},{3,7},{4,6,8},{5,7}};
    string start="", goal="123804765";
    int zeroPos;

    for(int i=0;i<3;i++){
        for(int j=0;j<3;j++){
            start+=to_string(grid[i][j]);
            if(grid[i][j]==0) zeroPos=3*i+j;
        }
    }

    queue<pair<string,int>> q;
    unordered_set<string> visited;
    q.emplace(start,zeroPos);
    visited.insert(start);
    int moves=0, sz;

    while(!q.empty()){
        sz=q.size();
        while(sz--){
            auto ele=q.front();
            q.pop();
            string state=ele.first;
            int pos=ele.second;
            if(state==goal)
                return moves;
            for(int next:dir[pos]){
                swap(state[pos],state[next]);
                if(!visited.count(state)){
                    visited.insert(state);
                    q.emplace(state,next);
                }
            }
        }
        moves++;
    }
    return -1;
}

int main(){
    vector<vector<int>> grid(3,vector<int>(3));
    cout<<"Enter
the initial 3x3 grid (use 0 for blank):\n";
    for(int i=0;i<3;i++)
        for(int j=0;j<3;j++) cin>>grid[i][j];
}
```

```
int result=solve8Puzzle(grid);
if(result!=-1) cout<<"Solved in "<<result<<" moves.\n"; else
cout<<"Unsolvable puzzle.\n";

    return 0;
}
```

Output:

```
Enter the initial 3x3 grid (use 0 for blank):
1 2 4
3 0 8
5 7 6
Solved in 57 moves.
```

Experiment 2

Aim: Write a program to solve the 8-Puzzle problem using DFID Technique.

Code:

```
#include<bits/stdc++.h>
using namespace std;

vector<vector<int>> dir={{1,3},{0,2,4},{1,5},{0,4,6},{1,3,5,7},{2,4,8},{3,7},{4,6,8},{5,7}}; string
goal="123804765";

bool DLS(string state, int pos, int depth, unordered_set<string> &visited){    if(state==goal) return true;
    if(depth==0) return false;

    visited.insert(state);    for(int next:dir[pos]){
        swap(state[pos],state[next]);
        if(!visited.count(state)){
            if(DLS(state, next, depth-1, visited)) return true;
        }
        swap(state[pos],state[next]);
    }
    visited.erase(state);
    return false;
}

int DFID(vector<vector<int>> &grid){    string
start="";    int zeroPos;    for(int i=0;i<3;i++)
for(int j=0;j<3;j++){        start += to_string(grid[i][j]);
        if(grid[i][j]==0) zeroPos = 3*i + j;
    }

    for(int depth=0; depth<=50; depth++){        unordered_set<string>
visited;        if(DLS(start, zeroPos, depth, visited)) return depth;
    }
    return -1;
}

int main(){
    vector<vector<int>> grid(3,vector<int>(3));    cout<<"Enter the initial 3x3
grid (use 0 for blank):\n";    for(int i=0;i<3;i++)
for(int j=0;j<3;j++) cin>>grid[i][j];

    int result = DFID(grid);    if(result != -1) cout<<"Solved in "<<result<<" moves using
DFID.\n";    else cout<<"Unsolvable puzzle (or exceeds depth limit).\n";

    return 0;
}
```

Output

Enter the initial 3x3 grid (use 0 for blank):

1 2 4

3 0 8

5 7 6

Solved in 33 moves using DFID.

Experiment 3

Aim: Write a program to solve the 3-SAT Problem using Variable Neighbourhood Descent Algorithm.

Code:

```
#include<bits/stdc++.h>
using namespace std;

using Clause = vector<int>;
using Formula = vector<Clause>;

int evaluate(Formula &formula, vector<bool> &assignment) {    int
satisfied = 0;
    for(const auto &clause : formula){        for(int lit : clause){
int var = abs(lit) - 1;            bool val = (lit > 0) ? assignment[var] :
!assignment[var];            if(val){ satisfied++; break; }
        }
    }
    return satisfied;
}

bool VND(const Formula &formula, int nVars, vector<bool> &assignment){
int totalClauses = formula.size();    int bestScore = evaluate(formula,
assignment);

    while(true){        bool improved =
false;        for(int i=0;i<nVars;i++){
assignment[i] = !assignment[i];
            int newScore = evaluate(formula, assignment);
if(newScore > bestScore){                bestScore =
newScore;                improved = true;
                break;
            } else assignment[i] = !assignment[i];
        }
        if(!improved) break;
    }

    return bestScore == totalClauses;
}

int main(){
    int nVars=3, nClauses;
    cout << "Enter number of clauses: ";    cin
>> nClauses;

    Formula formula(nClauses);    cout << "Enter clauses
(use negative for negation):\n";    for(int
i=0;i<nClauses;i++){        Clause clause(3);
        for(int j=0;j<3;j++) cin >> clause[j];
formula[i] = clause;
    }
}
```

```

}

for(int attempt=0;attempt<1000;attempt++){
    vector<bool> assignment(nVars);
    for(int i=0;i<nVars;i++) assignment[i] = rand()%2;

    if(VND(formula, nVars, assignment)){
        cout << "Satisfiable
assignment found:\n";
        for(int i=0;i<nVars;i++) cout << "x" << (i+1) << "=" << assignment[i] << "\n";
        return 0;
    }

    cout << "No satisfying assignment found (may be unsatisfiable).\n";
}

```

Output:

```

Enter number of clauses: 5
Enter clauses (use negative for negation):
3 -1 2
2 3 -1
-2 1 3
-3 -1 -2
-2 -3 1
Satisfiable assignment found:
x1 = 1
x2 = 1
x3 = 0

```

Experiment-4

Aim: Write a program to solve the 3- SAT Problem using Stochastic Hill Climbing Algorithm.

Code:

```
#include<bits/stdc++.h>
using namespace std;

using Clause = vector<int>;
using Formula = vector<Clause>;

int evaluate(Formula &formula, vector<bool> &assignment) {    int
satisfied = 0;
    for(const auto &clause : formula){
        for(int lit : clause){            int var =
abs(lit) - 1;
            bool val = (lit > 0) ? assignment[var] : !assignment[var];
            if(val){ satisfied++; break; }
        }
    }
    return satisfied;
}

bool stochasticHillClimbing(Formula &formula, int nVars, vector<bool> &assignment, int maxIter = 10000){
    int totalClauses = formula.size();
    int bestScore = evaluate(formula, assignment);

    for(int iter=0;iter<maxIter;iter++){
        int var = rand() % nVars;
        assignment[var] = !assignment[var];

        int newScore = evaluate(formula, assignment);
        if(newScore >= bestScore){            bestScore =
newScore;
            if(bestScore == totalClauses) return true;
        } else {
            assignment[var] = !assignment[var];
        }
    }

    return false;
}

int main(){
    srand(time(0));

    int nVars, nClauses;    cout << "Enter number of
variables and clauses: ";    cin >> nVars >> nClauses;

    Formula formula(nClauses);    cout << "Enter clauses
(use negative for negation):\n";    for(int
```

```

i=0;j<nClauses;i++){      Clause clause(3);      for(int
j=0;j<3;j++) cin >> clause[j];      formula[i] = clause;
}

for(int attempt=0;attempt<100;attempt++){
    vector<bool> assignment(nVars);
    for(int i=0;i<nVars;i++) assignment[i] = rand() % 2;

    if(stochasticHillClimbing(formula, nVars, assignment)){
        cout << "Satisfiable assignment
found:\n";
        for(int i=0;i<nVars;i++)
            cout << "x" << (i+1) << " = " << assignment[i] << "\n";
        return 0;
    }
}

cout << "No satisfying assignment found (may be unsatisfiable).\n";  return 0;
}

```

Output:

```

Enter number of clauses: 5
Enter clauses (use negative for negation):
3 -1 2
2 3 -1
-2 1 3
-3 -1 -2
-2 -3 1
Satisfiable assignment found:
x1 = 0
x2 = 0
x3 = 1

```

Experiment-5

Aim: Write a program to solve the 8-Puzzle problem using A* algorithm.

Code:

```
#include<bits/stdc++.h>
using namespace std;

int heuristic(string &state, string &goal){    int cnt=0;
    for(int i=0;i<9;i++) cnt+=(state[i]!=goal[i]);    return cnt;
}

int solve8PuzzleAStar(vector<vector<int>> &grid){    vector<vector<int>>
dir={{{1,3},{0,2,4},{1,5},{0,4,6},{1,3,5,7},{2,4,8},{3,7},{4,6,8},{5,7}}};    string start="", goal="123804765";
    int zeroPos;

    for(int i=0;i<3;i++)        for(int j=0;j<3;j++){
start+=to_string(grid[i][j]);
        if(grid[i][j]==0) zeroPos=3*i+j;
    }

    using State=tuple<int,int,string,int>; // f, g, state, pos
priority_queue<State,vector<State>,greater<State>> pq;    unordered_set<string> visited;

    int h=heuristic(start,goal);    pq.emplace(h,0,start,zeroPos);
    visited.insert(start);

    while(!pq.empty()){
        State S=pq.top(); pq.pop();
        int f=get<0>(S), g=get<1>(S), pos=get<3>(S);
        string state=get<2>(S);    if(state==goal) return g;
        for(int next:dir[pos]){
            swap(state[pos],state[next]);
            if(!visited.count(state)){
                int h=heuristic(state,goal);
                pq.emplace(g+1+h,g+1,state,next);
                visited.insert(state);
            }
            swap(state[pos],state[next]);
        }
        return -1;
    }

    int main(){
        vector<vector<int>> grid(3,vector<int>(3));    cout<<"Enter the initial 3x3 grid
(use 0 for blank):\n";    for(int i=0;i<3;i++)
        for(int j=0;j<3;j++) cin>>grid[i][j];

        int result=solve8PuzzleAStar(grid);
        if(result!=-1) cout<<"Solved in "<<result<<" moves using A*.\n";
        else cout<<"Unsolvable puzzle.\n";

        return 0;
    }
}
```

```
}
```

Output:

```
Enter the initial 3x3 grid (use 0 for blank):
```

```
1 2 4
```

```
3 0 8
```

```
5 7 6
```

```
Solved in 22 moves using A*.
```

Experiment 6

Aim: Write a program to solve AND OR Graph using AO* Search Algorithm.

Code:

```
#include <bits/stdc++.h>
using namespace std;

struct Node {    string name;
    vector<vector<string>> children;    vector<int> costs;    bool
solved = false;    int finalCost = INT_MAX;
    vector<string> solution;
};

unordered_map<string, Node> graph;

// Function to recursively apply AO* Search pair<vector<string>, int> aoStar(string nodeName)
{
    Node &node = graph[nodeName];

    if (node.solved) return {node.solution, node.finalCost};

    // Goal node (no children)    if (node.children.empty()) {
node.solved = true;    node.finalCost = 0;    node.solution
= {nodeName};
        return {node.solution, 0};
    }

    int minCost = INT_MAX;
    vector<string> bestSol;

    for (int i = 0; i < node.children.size(); ++i) {        int cost =
node.costs[i];        vector<string> tempSol = {nodeName};
        int subCost = 0;
        bool allSolved = true;

        for (const string &child : node.children[i]) {
vector<string> sol=ele.first;            int c=ele.second;
tempSol.insert(tempSol.end(), sol.begin(), sol.end());            auto ele = aoStar(child);
            if (graph[child].solved) {
                subCost += c;
            } else {
                allSolved = false;
                break;
            }
        }

        if (allSolved && cost + subCost < minCost) {            minCost = cost + subCost;
            bestSol = tempSol;
        }
    }

    node.solved = true;    node.finalCost = minCost;    node.solution =
bestSol;
    return {bestSol, minCost};
}
```

```

int main() {
    graph["g1"] = {"g1", {}, {}, true, 0, {"g1"}};
    graph["g2"] = {"g2", {}, {}, true, 0, {"g2"}};
    graph["g3"] = {"g3", {}, {}, true, 0, {"g3"}};

    graph["b"] = {"b", {"g1"}, {1}};
    graph["c"] = {"c", {"g2", "g3"}, {2}};

    graph["a"] = {"a", {"b", "c"}, {1, 2}};

    auto ele = aoStar("a");
    vector<string> solution=ele.first;
    int cost=ele.second;

    cout << "AO* Solution Path: ";
    for (auto &node : solution) cout << node << " ";
    cout << "\nTotal Cost: " << cost << endl;

    return 0;
}

```

Output:

```

AO* Solution Path: a b g1
Total Cost: 2

```

Experiment-7

Aim: WAP to find maximum of two/three numbers. Code:

```
max2(X, Y, X) :- X >= Y.  
max2(X, Y, Y) :- X < Y.  
max3(X, Y, Z, Max) :-  
    max2(X, Y, TempMax),  
    max2(TempMax, Z, Max).
```

Output:

The screenshot shows the SWISH interface with the following details:

- Toolbar:** File ▾, Edit ▾, Examples ▾, Help ▾.
- Code Editor:** A tab labeled "Program" containing the Prolog code:

```
1 max2(X, Y, X) :- X >= Y.  
2 max2(X, Y, Y) :- X < Y.  
3 max3(X, Y, Z, Max) :-  
4     max2(X, Y, TempMax),  
5     max2(TempMax, Z, Max).
```
- Execution Results:** A stack of output boxes:
 - Box 1: **max2(5, 9, M).**
M = 9
 - Box 2: **max3(5, 8, 3, Max).**
Max = 8
false
 - Box 3: **?- max3(5, 8, 3, Max).**

Experiment 8

Aim: WAP to find factorial of a number.

Code:

```
factorial(0, 1). factorial(N, F) :- N > 0, N1 is N - 1, factorial(N1, F1),  
F is N * F1.
```

Output:

The screenshot shows the SWISH interface. On the left, there is a code editor window titled "Program" containing the Prolog code for calculating factorial. The code is as follows:

```
1 factorial(0, 1).
2 factorial(N, F) :- 
3     N > 0,
4     N1 is N - 1,
5     factorial(N1, F1),
6     F is N * F1.
```

On the right, the execution results are displayed in a terminal-like window. The query `?- factorial(6, F)` is entered, and the response is `F = 720`. Below the terminal window, there are buttons for "Next", "10", "100", "1,000", and "Stop".

Experiment-9

Aim: WAP to find sum of first N numbers.

Code:

```
sumFirstn(0, 0).
sumFirstn(N, Sum) :-  N > 0,
    N1 is N - 1,  sumFirstn(N1, S1),
Sum is N + S1.
```

Output:

The screenshot shows the SWISH interface with the following details:

- Code Area:** Displays the Prolog code for calculating the sum of the first N numbers. The code includes base case `sumFirstn(0, 0)` and a recursive rule `sumFirstn(N, Sum) :- N > 0, N1 is N - 1, sumFirstn(N1, S1), Sum is N + S1..
- Execution Area:** Shows the query `sumFirstn(11, S)` and its result $S = 66$. Below the result are buttons for "Next", "10", "100", "1,000", and "Stop".
- Query Area:** Shows the query `?- sumFirstn(11, S)`.

Experiment-10

Aim: Write a program to find Fibonacci sequence upto Nth term.

Code: fibonacci(0, [0]). fibonacci(1, [0, 1]). fibonacci(N, Seq) :- N > 1, fibonacci_helper(2, N, [1, 0], SeqRev), reverse(SeqRev, Seq).

```
fibonacci_helper(I, N, Acc, Acc) :- I > N.  
fibonacci_helper(I, N, [A, B | Rest], Seq) :- C is  
A + B, I1 is I + 1, fibonacci_helper(I1, N, [C,  
A, B | Rest], Seq).
```

Output:

The screenshot shows the SWISH IDE interface. The top menu bar includes File, Edit, Examples, and Help. A toolbar with icons for file operations is visible. The main window has a 'Program' tab open, displaying the Prolog code for generating a Fibonacci sequence. The code defines base cases for 0 and 1, and a recursive helper predicate that uses reverse and addition to build the sequence up to N. Below the code, a query window shows the result of executing `fibonacci(8, Fibs)`. The output is a list of integers: [0, 1, 1, 2, 3, 5, 8, 13, 21]. There are also buttons for 'Next', '10', '100', '1,000', and 'Stop'. At the bottom, a question mark prompt is followed by the query again: ?- fibonacci(8, Fibs).

```
fibonacci(0, [0]).  
fibonacci(1, [0, 1]).  
fibonacci(N, Seq) :-  
    N > 1,  
    fibonacci_helper(2, N, [1, 0], SeqRev),  
    reverse(SeqRev, Seq).  
  
fibonacci_helper(I, N, Acc, Acc) :- I > N.  
fibonacci_helper(I, N, [A, B | Rest], Seq) :-  
    C is A + B,  
    I1 is I + 1,  
    fibonacci_helper(I1, N, [C, A, B | Rest], Seq).  
  
?- fibonacci(8, Fibs)  
Fibs = [0, 1, 1, 2, 3, 5, 8, 13, 21]  
Next 10 100 1,000 Stop  
?- fibonacci(8, Fibs)
```