**Batch: IAI-2 Experiment Number: 6**

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**Aim of the Experiment:** Write a program for implementation of Prolog program on 8-Puzzle.

**Program/Steps:**

To solve an 8-puzzle you need to call the predicate solvepuzzle with the following parameters

* First parameter is the initial state.
* Second parameter is the goal state.
* Third parameter is a variable called Cost that returns the total cost to reach the desired configuration.

Example

solvepuzzle([[1,3,4],[8,0,5],[7,2,6]], [[1,2,3],[8,0,4],[7,6,5]],Cost).

If the puzzle is solvable it returns the total cost with each step to solve it.

If the puzzle is not solvable it returns "No soution".

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**Code:**

can\_it\_move\_left(Left):-

Left >= 0,

Left \= 2,

Left \= 5.

can\_it\_move\_right(Right):-

8 >= Right,

Right \= 3,

Right \= 6.

can\_it\_move\_down(Down):-

Down < 9.

can\_it\_move\_up(Up):-

Up > 0.

countInversions(\_,[],Inversions):-

Inversions is 0.

countInversions(Number,[Head|Tail],Inversions):-

Number>Head,

Count is 1,

countInversions(Number,Tail,Aux\_inversions),

Inversions is Count+Aux\_inversions.

countInversions(Number,[Head|Tail],Inversions):-

Number<Head,

Count is 0,

countInversions(Number,Tail,Aux\_inversions),

Inversions is Count+Aux\_inversions.

issolvable([],A):-

A is 0.

issolvable([Head|Tail],Inversions):-

countInversions(Head,Tail,Aux\_inversions),

issolvable(Tail,Next\_inversions),

Inversions is Next\_inversions+Aux\_inversions.

iseven(Number):-

0 is mod(Number,2).

solvepuzzle(Initial\_state,Goal\_state,Result):-

flatten(Initial\_state, List\_initial\_state),

delete(List\_initial\_state, 0, X),

issolvable(X,Inversions),

0 is mod(Inversions,2),

flatten(Goal\_state, List\_goal\_state),

delete(List\_goal\_state, 0, Y),

issolvable(Y,Inversions\_two),

0 is mod(Inversions\_two,2),

empty\_heap(Inital\_heap),

Explored\_set = [List\_initial\_state],

astar([List\_initial\_state,0],List\_goal\_state,Goal\_state,Inital\_heap,Explored\_set,Iterations),

copy\_term(Iterations, Result),

!.

solvepuzzle(Initial\_state,Goal\_state,Result):-

flatten(Initial\_state, List\_initial\_state),

delete(List\_initial\_state, 0, X),

issolvable(X,Inversions),

\+0 is mod(Inversions,2),

flatten(Goal\_state, List\_goal\_state),

delete(List\_goal\_state, 0, Y),

issolvable(Y,Inversions\_two),

\+0 is mod(Inversions\_two,2),

empty\_heap(Inital\_heap),

Explored\_set = [List\_initial\_state],

astar([List\_initial\_state,0],List\_goal\_state,Goal\_state,Inital\_heap,Explored\_set,Iterations),

copy\_term(Iterations, Result),

!.

solvepuzzle(\_,\_,Result):-

Result = 'No solution'.

create\_explored\_set(Old\_Set,Element,X):-

Aux = [Element],

append(Old\_Set,Aux,X).

divide\_list([Head|\_],Head).

print\_element([],\_).

print\_element([Head|Tail],I):-

0 is mod(I,3),

Newi=I+1,

nl,

print(Head),

print\_element(Tail,Newi).

print\_element([Head|Tail],I):-

Newi=I+1,

print(Head),

print\_element(Tail,Newi).

print\_list([],\_).

print\_list([Head|Tail],I):-

number(Head),

print\_list(Tail,I).

print\_list([Head|Tail],I):-

Newi=I+1,

print\_list(Tail,Newi),

print\_element(Head,0),

nl.

create\_list\_with\_new\_cost([],\_,\_,\_).

create\_list\_with\_new\_cost([Head|Tail],Iterator,Pos\_cost,[New\_cost|Tail]):-

Iterator == Pos\_cost,

New\_iterator is Iterator+1,

New\_cost is Head + 1,

create\_list\_with\_new\_cost(Tail,New\_iterator,Pos\_cost,Tail).

create\_list\_with\_new\_cost([Head|Tail],Iterator,Pos\_cost,[Head|Tail2]):-

New\_iterator is Iterator+1,

create\_list\_with\_new\_cost(Tail,New\_iterator,Pos\_cost,Tail2).

astar([Head|Tail],Head,\_,\_,\_,Result):-

append([Head],Tail,Fathers),

print\_list(Fathers,0),

length(Tail,Aux),

Result is Aux-1.

astar(State,Goal\_state,Grid\_goal\_state,Priority\_queue,Explored\_set,Result):-

divide\_list(State,State\_to\_esplore),

nth0(Position\_blank\_tile,State\_to\_esplore, 0),

length(State,Pos\_cost),

nth1(Pos\_cost, State, Cost),

New\_cost is Cost + 1,

create\_list\_with\_new\_cost(State,1,Pos\_cost,New\_state),

findcombinations(New\_state,Grid\_goal\_state,Position\_blank\_tile,0,Priority\_queue,New\_cost,Explored\_set,New\_priority\_queue),

get\_from\_heap(New\_priority\_queue, \_, P, Next\_priority\_queue),

divide\_list(P,Explored),

create\_explored\_set(Explored\_set,Explored,New\_explored\_set),

astar(P,Goal\_state,Grid\_goal\_state,Next\_priority\_queue,New\_explored\_set,Result).

astar(\_,\_,\_,Priority\_queue,\_,Result):-

empty\_heap(Priority\_queue),

Result = 'No solution'.

findcost([],\_,\_,Nextcost):-

Nextcost is 0.

findcost([Head|Tail],Matrixinitialstate ,Matrixgoalstate, Cost):-

Head == 0,

findcost(Tail,Matrixinitialstate ,Matrixgoalstate, Nextcost),

Cost is 0 + Nextcost.

findcost([Head|Tail], Matrixinitialstate ,Matrixgoalstate, Cost):-

matrix(Matrixgoalstate,K,L,Head),

matrix(Matrixinitialstate,I,J,Head),

Manhattan\_distance is abs(I-K) + abs(J-L),

findcost(Tail,Matrixinitialstate,Matrixgoalstate,Nextcost),

Cost is Manhattan\_distance + Nextcost.

convert\_to\_matrix(Lista,Nueva\_lista):-

aux\_convert\_to\_matrix(Lista,1,N1,T1),

aux\_convert\_to\_matrix(T1,1,N2,T2),

aux\_convert\_to\_matrix(T2,1,N3,\_),

append([N1],[N2],Aux),

append(Aux,[N3],Nueva\_lista),

!.

aux\_convert\_to\_matrix([Head|Tail], Iterator, [Head|Tail2], Sobra):-

Iterator < 3,

Nuevoi is Iterator+1,

aux\_convert\_to\_matrix(Tail,Nuevoi,Tail2, Sobra).

aux\_convert\_to\_matrix([Head|Tail], Iterator, [Head], Tail):-

0 is mod(Iterator,3).

create\_list\_of\_explored\_states(List,Element,New\_list):-

Aux = [Element],

append(Aux,List,New\_list).

findcombinations(State,Matrix\_goal\_state,Position\_blank\_tile,0,Old\_priority\_queue,Cost\_move\_grid,Explored\_set,New\_priority\_queue):-

divide\_list(State,State\_to\_esplore),

Left is Position\_blank\_tile - 1,

can\_it\_move\_left(Left),

swap\_tiles(State\_to\_esplore, Position\_blank\_tile, Left, Permutation\_left),

\+member(Permutation\_left,Explored\_set),

convert\_to\_matrix(Permutation\_left,Matrix\_per\_left),

findcost(Permutation\_left,Matrix\_per\_left,Matrix\_goal\_state,Cost),

create\_list\_of\_explored\_states(State,Permutation\_left,State\_with\_fathers),

New\_cost is Cost\_move\_grid + Cost,

add\_to\_heap(Old\_priority\_queue,New\_cost,State\_with\_fathers,Aux\_priority\_queue),

findcombinations(State,Matrix\_goal\_state,Position\_blank\_tile,1,Aux\_priority\_queue,Cost\_move\_grid,Explored\_set,New\_priority\_queue).

findcombinations(State,Matrix\_goal\_state,Position\_blank\_tile,0,Old\_priority\_queue,Cost\_move\_grid,Explored\_set,New\_priority\_queue):-

findcombinations(State,Matrix\_goal\_state,Position\_blank\_tile,1,Old\_priority\_queue,Cost\_move\_grid,Explored\_set,New\_priority\_queue).

findcombinations(State,Matrix\_goal\_state,Position\_blank\_tile,1,Old\_priority\_queue,Cost\_move\_grid,Explored\_set,New\_priority\_queue):-

divide\_list(State,State\_to\_esplore),

Right is Position\_blank\_tile + 1,

can\_it\_move\_right(Right),

swap\_tiles(State\_to\_esplore, Position\_blank\_tile, Right, Permutation\_right),

\+member(Permutation\_right,Explored\_set),

convert\_to\_matrix(Permutation\_right,Matrix\_per\_right),

findcost(Permutation\_right,Matrix\_per\_right,Matrix\_goal\_state,Cost),

create\_list\_of\_explored\_states(State,Permutation\_right,State\_with\_fathers),

New\_cost is Cost\_move\_grid + Cost,

add\_to\_heap(Old\_priority\_queue,New\_cost,State\_with\_fathers,Aux\_priority\_queue),

findcombinations(State,Matrix\_goal\_state,Position\_blank\_tile,2,Aux\_priority\_queue,Cost\_move\_grid,Explored\_set,New\_priority\_queue).

findcombinations(State,Matrix\_goal\_state,Position\_blank\_tile,1,Old\_priority\_queue,Cost\_move\_grid,Explored\_set,New\_priority\_queue):-

findcombinations(State,Matrix\_goal\_state,Position\_blank\_tile,2,Old\_priority\_queue,Cost\_move\_grid,Explored\_set,New\_priority\_queue).

findcombinations(State,Matrix\_goal\_state,Position\_blank\_tile,2,Old\_priority\_queue,Cost\_move\_grid,Explored\_set,New\_priority\_queue):-

divide\_list(State,State\_to\_esplore),

Down is Position\_blank\_tile + 3,

can\_it\_move\_down(Down),

swap\_tiles(State\_to\_esplore, Position\_blank\_tile, Down, Permutation\_down),

\+member(Permutation\_down,Explored\_set),

convert\_to\_matrix(Permutation\_down,Matrix\_per\_down),

findcost(Permutation\_down,Matrix\_per\_down,Matrix\_goal\_state,Cost),

create\_list\_of\_explored\_states(State,Permutation\_down,State\_with\_fathers),

New\_cost is Cost\_move\_grid + Cost,

add\_to\_heap(Old\_priority\_queue,New\_cost,State\_with\_fathers,Aux\_priority\_queue),

findcombinations(State,Matrix\_goal\_state,Position\_blank\_tile,3,Aux\_priority\_queue,Cost\_move\_grid,Explored\_set,New\_priority\_queue).

findcombinations(State,Matrix\_goal\_state,Position\_blank\_tile,2,Old\_priority\_queue,Cost\_move\_grid,Explored\_set,New\_priority\_queue):-

findcombinations(State,Matrix\_goal\_state,Position\_blank\_tile,3,Old\_priority\_queue,Cost\_move\_grid,Explored\_set,New\_priority\_queue).

findcombinations(State,Matrix\_goal\_state,Position\_blank\_tile,3,Old\_priority\_queue,Cost\_move\_grid,Explored\_set,New\_priority\_queue):-

divide\_list(State,State\_to\_esplore),

Up is Position\_blank\_tile -3,

can\_it\_move\_up(Up),

swap\_tiles(State\_to\_esplore, Position\_blank\_tile, Up, Permutation\_up),

\+member(Permutation\_up,Explored\_set),

convert\_to\_matrix(Permutation\_up,Matrix\_per\_up),

findcost(Permutation\_up,Matrix\_per\_up,Matrix\_goal\_state,Cost),

create\_list\_of\_explored\_states(State,Permutation\_up,State\_with\_fathers),

New\_cost is Cost\_move\_grid + Cost,

add\_to\_heap(Old\_priority\_queue,New\_cost,State\_with\_fathers,Aux\_priority\_queue),

findcombinations(State,Matrix\_goal\_state,Position\_blank\_tile,4,Aux\_priority\_queue,Cost\_move\_grid,Explored\_set,New\_priority\_queue).

findcombinations(State,Matrix\_goal\_state,Position\_blank\_tile,3,Old\_priority\_queue,Cost\_move\_grid,Explored\_set,New\_priority\_queue):-

findcombinations(State,Matrix\_goal\_state,Position\_blank\_tile,4,Old\_priority\_queue,Cost\_move\_grid,Explored\_set,New\_priority\_queue).

findcombinations(\_,\_,\_,4,Old\_priority\_queue,\_,\_,New\_priority\_queue):-

copy\_term(Old\_priority\_queue,New\_priority\_queue).

matrix(M, X, Y, Element) :-

nth0(X, M, R),

nth0(Y, R, Element).

swap\_tiles(List,Zero,Move,Nl):-

Ayuda is Move+1,

Zero==Ayuda,

nth0(Move,List, Number\_to\_find),

aux\_swap\_tiles(List,Move,0,New\_list,\_,List\_to\_explore\_more),

append(New\_list,[0],Nl\_aux),

append(Nl\_aux,[Number\_to\_find],Nl\_aux2),

delete(List\_to\_explore\_more, 0, X),

append(Nl\_aux2,X,Nl),

!.

swap\_tiles(List,Zero,Move,Nl):-

Ayuda is Move-1,

Zero==Ayuda,

nth0(Move,List,Number\_to\_find),

aux\_swap\_tiles(List,Zero,0,New\_list,\_,List\_to\_explore\_more),

append(New\_list,[Number\_to\_find],Nl\_aux),

append(Nl\_aux,[0],Nl\_aux2),

delete(List\_to\_explore\_more, Number\_to\_find, X),

append(Nl\_aux2,X,Nl),

!.

swap\_tiles(List,Zero,Move,Nl):-

Ayuda is Move+1,

Ayuda\_dos is Move-1,

Zero<Move,

\+Zero==Ayuda,

\+Zero==Ayuda\_dos,

nth0(Move,List, Number\_to\_find),

aux\_swap\_tiles(List,Zero,0,New\_list,Current\_iterator,List\_to\_explore\_more),

append(New\_list,[Number\_to\_find],Nl\_aux),

aux\_swap\_tiles(List\_to\_explore\_more,Move,Current\_iterator+1,New\_list\_two,\_,List\_to\_explore\_more\_two),

append(Nl\_aux,New\_list\_two,Nl\_aux\_two),

append(Nl\_aux\_two,[0],Nl\_aux\_three),

append(Nl\_aux\_three,List\_to\_explore\_more\_two,Nl),

!.

swap\_tiles(List,Zero,Move,Nl):-

Ayuda is Move+1,

Ayuda\_dos is Move-1,

Zero>Move,

\+Zero==Ayuda,

\+Zero==Ayuda\_dos,

nth0(Move,List, Number\_to\_find),

aux\_swap\_tiles(List,Move,0,New\_list,Current\_iterator,List\_to\_explore\_more),

append(New\_list,[0],Nl\_aux),

aux\_swap\_tiles(List\_to\_explore\_more,Zero,Current\_iterator+1,New\_list\_two,\_,List\_to\_explore\_more\_two),

append(Nl\_aux,New\_list\_two,Nl\_aux\_two),

append(Nl\_aux\_two,[Number\_to\_find],Nl\_aux\_three),

append(Nl\_aux\_three,List\_to\_explore\_more\_two,Nl),

!.

aux\_swap\_tiles([\_|Tail],Limit,Iterator,[],X,Tail):-

Iterator==Limit,

copy\_term(Iterator,X).

aux\_swap\_tiles([Head|Tail],Limit,Iterator,[Head|Tail2],X,List\_to\_explore\_more):-

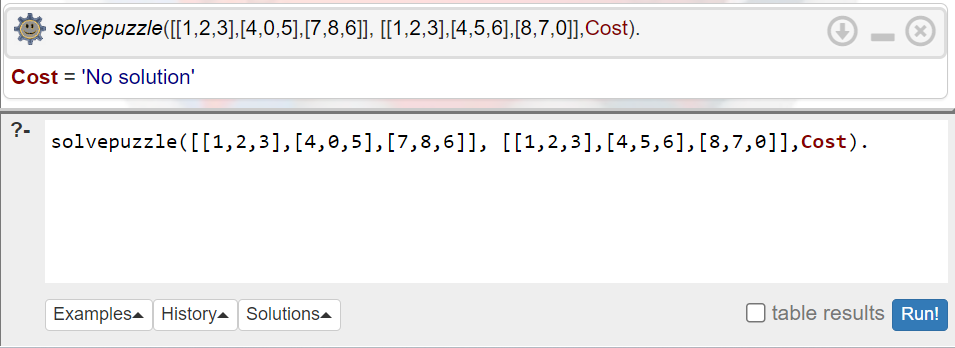
Iterator<Limit,

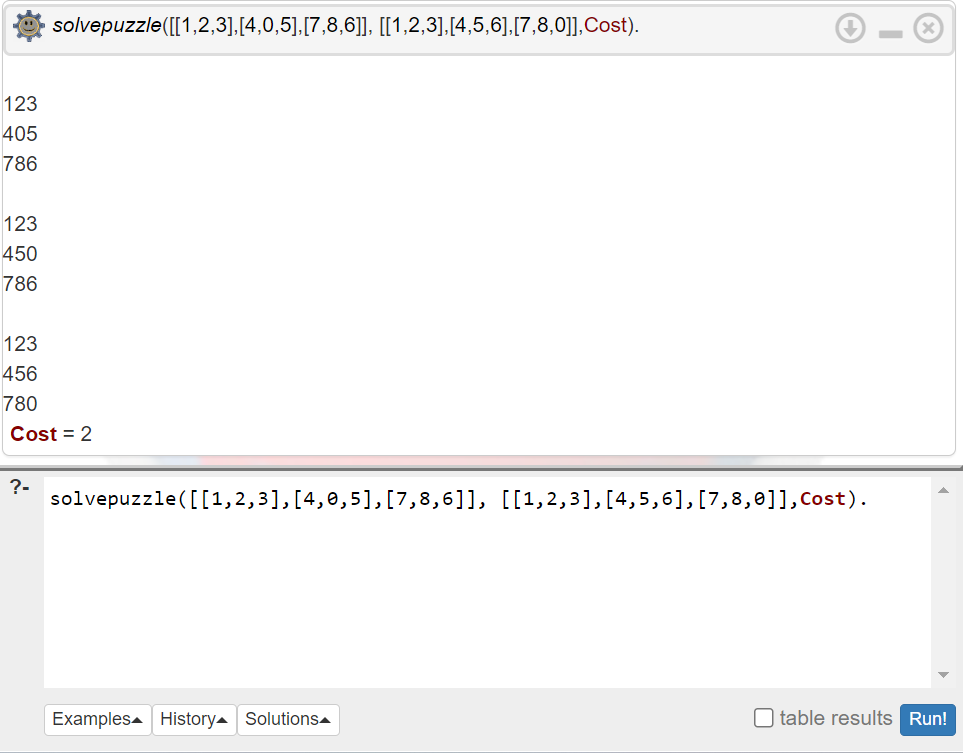
New\_iterator is Iterator+1,

aux\_swap\_tiles(Tail,Limit,New\_iterator,Tail2,X,List\_to\_explore\_more).

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**Output/Result:**

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**Outcomes: Ability to formally state the problem and develop the appropriate proof for a given logical deduction problem.**

**Conclusion (Based on the Results and outcomes achieved):**

The experiment on implementing an 8-Puzzle solver with Prolog demonstrated Prolog's efficacy in complex problem-solving, leveraging its backtracking and state space search capabilities. This implementation highlighted Prolog's potential in logic programming and AI applications, emphasizing its strength in managing state transitions and achieving goals logically. The success of this project not only showcased Prolog's adaptability to challenging puzzles but also underscored its broader applicability in developing intelligent systems, marking a promising avenue for future AI and computational logic explorations.

**References:**

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2. Luger, George F. Artificial Intelligence : Structures and strategies for complex problem solving, 2009, 6th Edition, Pearson Education
3. Ivan Bratko, Prolog Programming for AI, 2011, 4th Edition, Pearson Publication

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