CMSC 330: Organization of Programming Languages

Project 6 – Maze Solver & SAT in Prolog

Project 6

1. Implement recursive functions in Prolog
   - Some can be used to solve maze
2. Implement maze solver
3. Implement boolean formula evaluator

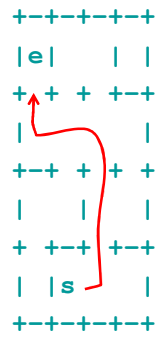
- Learn to use
  - Lists
  - Recursion
  - Backtracking

Part 1 – Recursion

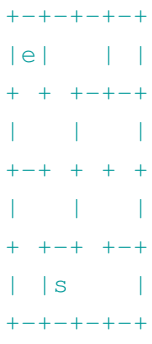
- prod(L,R)
  - R = product of all ints in L
- fill(N,X,R)
  - R = list of N copies of X
- genN(N,R)
  - 0 ≤ R ≤ N-1, in order
- genXY(N,R)
  - R = [X,Y], 0 ≤ X,Y ≤ N-1 in order
- flat(L,R)
  - R = elements of L, concatenated in single list

Part 2 – Maze

- 2D square maze with walls separating cells
- Start & end located anywhere in maze
- Examples



Solvable



Unsolvable

Part 2 – Maze Specification

- Maze
  - An n × n array of cells
  - With specified starting & end cell
  - May include paths
- Cells
  - May have openings in walls
    - Specified as udlr → up, down, left, right
  - Each opening has a weight
- Paths
  - Sequence of directions (udlr) from starting cell

Part 2 – Analyze & Process Maze

- Find maze properties
  - Number of closed cells
  - Number of openings of each type (udlr)
- Find all valid paths
  - Path invalid if does not pass through opening
  - Path does not need to go from maze start to finish
  - Cost of path = sum of weight of each opening on path
- List maze locations by distance from start
  - [[0,[[1,2]]],[1,[[1,1],[1,3]],…]
- Decide whether maze is solvable

Part 2 – Maze Specification in Prolog

- Maze given in database as 3 types of facts
  - Maze info (Size, StartX, StartY, EndX, EndY)
    - maze(4,0,3,0,0).
  - Cell info (Xcoord, Ycoord, OpeningList, WeightList)
    - cell(0,0,[d],[0.391538986557049]).
    - cell(1,0,[r,d],[16.597130417636, 0.889878639213553]).
  - Path info (PathName, StartX, StartY, DirectionList)
    - path("path1",0,3,[u,r,u,l,u]).
    - path("path2",0,3,[u,r,r,u,l,l,u]).
- Access maze information as queries
  - maze(X,_,_,_).
  - X = 4.

Part 3 – Boolean Formulae

- Representation
  - Booleans → t, f
  - Variables → x, y, z, etc…
  - Operations → no, and, or, every, exists
    - Represented as lists
      - [no, x], [and, x, y], [exists, x, x]
    - May be nested
      - [no, [and, x, [exists, x, x]]]
  - Variable assignments → lists of true variables
    - Variables not in assignment are false

Part 3 – Boolean Functions

- Evaluation
  - eval(F,A,R)
    - R is t if formula F is true with assignment A, f otherwise
- VarsOf
  - varsOf(F,R)
    - R is list of free variables in F (in sorted order, no duplicates)
- Satisfiability
  - sat(F,R)
    - R is assignment that satisfies F
    - R = [ ] if all assignments satisfy F
    - R = [ ] if all false variables satisfy F (unfortunately same)

Project Files

- Your code
  - logic.pl
- Public tests
  - publicRecursion1.pl, publicRecursion2.pl
  - publicMaze1.pl, publicMaze2.pl
  - publicEval.pl, publicVarsOf.pl, publicSat.pl
- Utility files
  - goTest.pl - test driver for all public tests

Public Tests

- Contain following test goals
  - public_fill
  - public_genN
  - public_genXY
  - public_flat
  - public_stats
  - public_validPath
  - public_findDistance
  - public_solve
  - public_eval, public_varsOf, public_sat

Differences From Project 1 & 3

- Utilize backtracking in Prolog
  - Return single answer, instead of list of answers
  - Request additional answers by typing `;`
- Tests will collect all answers, using Prolog utils
  - Findall – list of all answers
  - Setof – order list of all answers (duplicates removed)

Using Prolog From Terminal / Shell

- Go to directory p6 (from p6.zip) containing proj files
  - E.g., cd c:Users\myname\Desktop\p6
- Start Prolog interpreter
  - Type **`swipl`**
- Load Prolog code
  - Type **`['logic.pl'].`**
  - Type **`['publicRecursion1.pl'].`**
- Run public tests
  - Type **`public_fill.`**
  - Etc…

Using Prolog From Terminal / Shell

- To run all public tests
  - Type **`['goTest.pl'].`**
  - Type **`run.`**
- To modify your code
  - Edit logic.pl
  - Type **`make.`**

Using Prolog From Windows

- Open folder p6 (from p6.zip) containing project files
- Start Prolog interpreter
  - Right click goTest.pl, select Open With -> swipl-win.exe
  - Terminal window opens running Prolog interpreter
    - goTest.pl loaded at same time
- To run all public tests
  - Type **`run.`**
- To modify your code
  - Edit logic.pl
  - Type **`make.`**