INFO8006 Introduction to Artificial Intelligence

Exercises 2: Constraint satisfaction problems

Learning outcomes

At the end of this exercise session you should be able to:

- define a search problem as a constraint satisfaction problem (CSP).
- draw the constraint graph of a CSP.
- define what backtracking is and know how to use it.
- define and apply variable and value ordering.
- understand the syntax and the semantic of propositional logic.
- check the entailment of two propositions.
- show how a SAT problem can be formulated as a CSP.

Exercise 1: 8 Queens

The eight queens puzzle is the problem of placing eight chess queens on an 8×8 *chessboard so that no two queens threaten each other. Thus, a solution requires that no two queens share the same row, column, or diagonal. The eight queens puzzle is an example of the more general n queens problem of placing n non-attacking queens on an* $n \times n$ *chessboard, for which solutions exist for all natural numbers n with the exception of n=2 and n=3.* Consider the case where the chessboard size $n = 4$. Answer the following questions:

1. Define the problem as a CSP (implicit constraints are allowed).
2. Draw the graph of constraints from your CSP formulation.
3. Use backtracking search to find a solution.

Exercise 2: Propositional logic

Consider the following propositions:

- If he studies well, he will pass the exam.
- If he does not like the course, he will not study well.
- He passed the exam.
- Therefore he liked the course.

Is the conclusion really a logical consequence of the facts?

1. Represent each sentence by a propositional logic formula.
2. Give the models of each formula.
3. Does the last sentence follow logically from the three first?
4. Answer the previous question through the CSP formulation of the corresponding SAT problem.

Exercise 3: Minesweeper (AIMA, Ex 7.22)

Minesweeper (see Figure 1), the well-known computer game, is closely related to the wumpus world. A minesweeper world is a rectangular grid of N squares with M invisible mines scattered among them. Any square may be probed by the agent; instant death follows if a mine is probed. Minesweeper indicates the presence of mines by revealing, in each probed square, the number of mines that are directly or diagonally adjacent. The goal is to probe every unmined square. Let $X_{i,j}$ be true iff square $[i, j]$ contains a mine.

1. Write down the assertion that exactly two mines are adjacent to $[1, 1]$ as a sentence involving some logical combination of $X_{i,j}$ propositions.
2. Consider the configuration shown in Figure 1. Express the constraints implied by this configuration and perform a backtracking search to determine the position of the 2 mines.

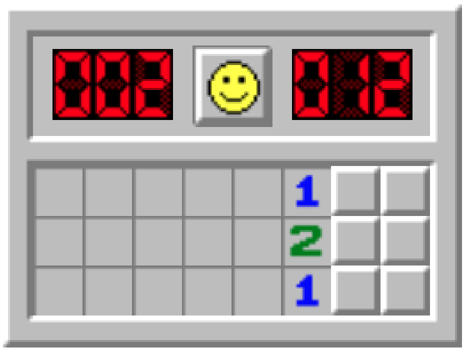

Figure 1: Minesweeper with $N = 24$ and $M = 2$

Exercise 4: K-Knights ⋆ (AIMA, Ex 6.2)

Consider the problem of placing k knights on an $n \times n$ chessboard such that no two knights are attacking each other, where k is given and $k \leq n^2$.

1. Choose a CSP formulation. In your formulation, what are the variables?
2. What are the possible values of each variable?
3. What sets of variables are constrained, and how?

Exercise 5: More propositional logic ⋆ (AIMA, Ex 7.2)

Given the following, can you prove that the unicorn is mythical? How about magical? Horned?
If the unicorn is mythical, then it is immortal, but if it is not mythical, then it is a mortal mammal. If the unicorn is either immortal or a mammal, then it is horned. The unicorn is magical if it is horned.

Supplementary materials

Sudoku

Berkeley 1

A nice and short CSP synthesis