Artificial Intelligence and Knowledge Engineering Laboratory

Task 2. Constraint Satisfaction Problem

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Task Objectives

Getting familiar with algorithms for Constraint Satisfaction Problems in practice through individual implementation.

Subtasks

- Get familiar with backtracking search algorithm and forward checking heuristic
- Analyse both problems shortly described below
- Formulate them as a CSP problems, i.e. define: variables, their domains and constraints in a formal or at least semi-formal way
- Implement backtracking algorithms for the chosen problem and enhance them with forward checking heuristics
- Test the implementations with problems of different sizes, i.e. for different sizes of the boards (n x m), number of letters to be used, and the number words to be used on the board, whenever it is relevant to the given problem.
- Present most interesting results: solutions and numerical results (e.g. execution times, also for problems that cannot be solved).
- Discuss the results.
- The report should contain all the above points (except the implementation).

Warming up Problem: Letter Mosaic
Write a CSP-based program to find a solution to the following problem. There is a rectangular board of n x m fields. Fill the fields with k letters given as a part of the problem definition in such a way that any two horizontally or vertically consecutive fields are not filled with the same letter.
If there is no solution, then the program should inform about this.

Entertaining Problem: Crossword Design
There is a board of size: n x m fields to be used as a canvas for a crossword. A set S of all English words (or for any other natural language) can be used to select words from, but only k of them can be used in a crossword. The problem parameters are: S, n, m and k. We need to find such a way of placing words across the board that one field includes at most one letter and every continuous sequence of letters read horizontally or vertically is a word from the selected subset of the size k of S. A solution must include exactly k words from S. Some fields of the board can be left empty.
S is to be acquired in the following way

a) download the list of English lemmas extracted from the British National Corpus prepared by Prof. Adam Kilgarriff: https://www.kilgarriff.co.uk/bnc-readme.html
b) select from the list only: adverbs (adv), verbs (v), adjectives (a) and nouns (n)

Task rating

2 points – formulate the problems as CSP
3 points – implement backtracking and forward checking CSP for them
3 points – compare efficiency of processing for various problem parameters
2 points – give a correct interpretation of the results

Exciting Problem for 5 Extra Points.
Formulate the problem below as a CSP problem and write a program solving it on the basis of the CSP program for the first problem.

Playing Scrabble is in fact searching for an optimal combination. In a slightly simplified version, a player selects randomly a sequence of letters with repetitions. Every letter is assigned some score points (see https://en.wikipedia.org/wiki/Scrabble_letter_distributions). There is a board of the size n x m with cells to store letters (at most one letter in a cell).
The player needs to form words from letters selected and put the on the board in way identical to the first problem. However, now, the task is to use as many letters as possible and to achieve as large sum of the scores from the individual letters used as possible. Only words from a subset of the size k of the set S (see the basic problem) are accepted as proper words.

Bibliography

1. Lecture notes
2. Russell and Norvig: http://aima.cs.berkeley.edu/2nd-ed/newchap05.pdf