Fall 2022 - CSC545/645 Artificial Intelligence - Assignment 5

Due date: Thursday, October 6, 2022, 2:00pm. Please create a folder called assignment5 in your local working copy of the repository and place all files and folders necessary for the assignment in this folder. Once done with the assignment, add the files and folders to the repo with svn add *files,folders* and then commmit with svn ci -m "SOME USEFUL MESSAGE" *files,folders* .

The Four Color problem is one of the most famous problems in Mathematics. The problem consists of the question whether any map can be colored using four colors in such a way that adjacent regions (i.e. those sharing a common boundary segment, not just a point) receive different colors. This problem has been formulated first by Francis Guthrie in 1852 (published in 1878) and was unsolved for roughly a century. Wolfgang Haken und Kenneth Appel could prove the four color theorem with the help of a computer program in 1977 [Ken77].

Exercise 5.1 [20 points]

Read chapter 6 of the textbook. Consider the political map of the South-Eastern states of the USA (states North Carolina, South Carolina, Virginia, Tennessee, Kentucky, West Virginia, Georgia, Alabama, Mississippi, and Florida). How can we color this map with the four color theorem using a CSP approach?

1. How is this problem represented in general (write in your own words). Define the variables, the value domain and the constraints. [2 points]

Variables: The states

Values: The colors they can be

Constraints: States with borders cannot have the same color

2. Implement your algorithm using backtracking, backtracking with forward checking, backtracking with AC-3, and min-conflicts.

Please run the algorithms with and without an initial assignment for one state. Construct a table of average run times for each al gorithm for values and show the results. Comment on your results.

Backtrack w/ Initial	.16097 seconds
Backtrack wo/ Inital	.17333 seconds
Backtrack w/ Forward Check w/ Inital	0.0 seconds (can prove its running by printing the answer growing, just gets an answer really quick!!)
Backtrack w/ Forward Check wo/ Inital	0.0 seconds
Backtrack /w AC-3 w/ Inital	0.0 seconds
Backtrack w/ AC-3 wo/ Inital	.000000997 seconds
Min-Conflicts w/ Inital	.00199 seconds
Min-Conflicts wo/ Inital	.00169 seconds

[15 points]

Since AC-3 is obviously the most technical, its suprising to see that Forward Check slightly beats it out, but Im sure thats because this problem is relatively small. I would assume AC-3 beats it in larger problems, but since AC-3 builds off of forward check this problem we are asking of it isnt wide enough (or deep enough) to get the benefits it. I am surprised how well Min-Conflicts works though and that there arent chaining conflicts that cause a ton of issues - again though this may be due to the size of the problem set. Backtracking alone, and therefore obviously with exra additions, seems to run much better than last week's genetic algorithm and seems to be the better way to solve this.

3. You have implemented the same problem with different algorithms (assignment 4+5). What have you learned from the two exercises? Is there a preference of one algorithm over the other? If yes, please comment on that. If no, please do the same :-).
[3 points]

I personally believe that the idea and potential for genetic algorithms is inherently super ool and helpful in a ton of situations, however this problem set is not the best display of why genetic algorithms are useful. The set up for each assinment took a while to understand and figure out how to properly check for, but once I had the set up the actual backtracking algorithm and adding forward check was incredibly simple, espically for how much it improved the runtime compared to the genetic algorithm. Backtracking also didnt need any new objects and hoping for randomness and splicing children, it just needed some equal signs and if statements. Although I would love to use genetic algoritms in a different way and explore cooler possibilities (like the in-class example of simulating a dogs limbs which the genetic algoritm figures out it should just use the elbows) I would greatly prefer backtracking, especially for this type of problem where variables, values, and constraints are so obvious.

Figure 1: South-Eastern states of the US

Exercise 5.2 *Mandatory for CSC645 students, optional for CSC545 students* [6 extra points]
In addition to the heuristics implemented in 5.1.2, implement the backtracking search with 1. degree heuristic, 2. least-constraining-value, 3. minimum-remaining-values. Also, evaluate the different implementations with the map of the entire USA and the Sudoku puzzle (provided with the Java framework) to see the differences of the algorithm more apparent.
[6 points]

You may want to use the framework provided by Alexander H¨artl (download Java).

References

[Ken77] Kenneth Appel and Wolfgang Haken. Every planar map is four colorable. Part I. Discharging. *Illinois Journal of Math*, 21:429–490, 1977.