Fall 2022 - CSC545/645 Artificial Intelligence - Assignment 4

Due date: Thursday, September 29, 2022, 2:00 pm. Please create a folder called assignment4 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 4.1 [4 points]
Read chapter 4.1 – 4.2 and 6.1 – 6.2 of the textbook.

1. Define in your own words the terms constraint satisfaction problem, constraint, back-tracking search, back-jumping, and min-conflicts. [2.5 points]

   Constraint Satisfaction Problem: We have a defined set of variables that can take on only a defined set of values. By checking to see if the set of variables and their values create an answer, and by using fitness functions to see how close they are to an answer, you create a CSP.

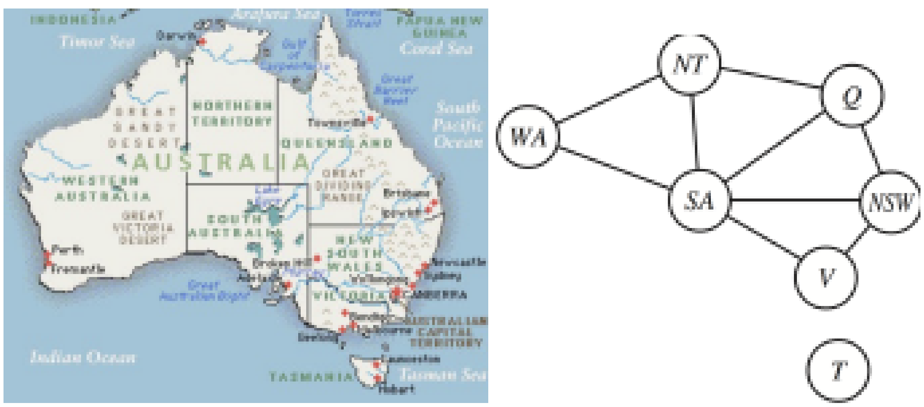
   Constraint: Explicitly describes the values variables are allowed to take on in a given problem.

   Back-tracking Search: Instead of generating all possible successors from a given state, each successor is made individually, remembering its state when it was made, and changing the "parent" to the "successor" using the same memory, briefly overwriting the parent state.

   Back-jumping: Once a set has reached an end with no possible way out, the program can read back through the set of changes made to the variables and find which one may have been the root of the issue and "jump back" to that state to start a new search.

Min-conflicts: A heuristic-like function that aims to change the state of some variable into a new state which results in the least amount of conflicts at the current time. Although it may generate more conflicts in the future, at the moment it is the best state, which is why it is heuristic-like.

2. How many solutions are there for the three-color map-coloring problem in Figure 1? Elaborate your answer.[1.5 points]



(a)

States and Territories (b) Constraint-graph

Figure 1: a) The principal states and territories of Australia. b) The map-coloring problem represented as a constraint graph.

We learned in class the most efficient way to solve this is to consider SA and then move clockwise. SA can be any three colors, which leaves WA and NT to be opposite, Q and NSW to be opposite, which means V = WA = Q and NT = NSW, then T can be any 3.

This leaves (3 SA's * 2 ways the remaining 2 sets can alternate * 3 T colors) = **18 possible solution sets.**

Exercise 4.2 [16 points]

Consider the political map of the South-Eastern states of the US (states North Carolina, South Carolina, Virginia, Tennessee, Kentucky, West Virginia, Georgia, Alabama, Mississippi, and Florida, see Figure 2). How can we color this map with the four color theorem using a Genetic Algorithm? Use the same algorithm to color al 51 states of the USA (Washington DC is counted as a state in this case).

1. How is this problem represented in general (write in your own words). Define the states, the goal-test, and the successor function of your problem.
   [2 points]

   The states are just potential-solution sets of the US States colored in various combinations of 4. This can be a string with numbers 0-3 and each index represents a state.

   The goal-test sees if, for each state, if any neighboring state shares the same color. If the total number of “yep, my neighbor doesnt share the same color” matches the total number of times that is asked - the total number of borders - then we have found a state that is a potential goal state!

   We can find successive states genetically by splicing the string at any random point, and conjoining it with another string spliced from that same point to the end. Finally, we can cause a mutation by randomly picking an index and changing that number.

2. Implement your algorithm and show the results. You may want to use the framework provided by Alexander H¨artl (download Java, C++, C). Fan Zhang has created a Python Framework which can be found here: Python). Neighboring states can be found in text files provided by Andreas Seekircher us states 10 ij.txt and us states 51 ij.txt
[14 points]

I was **unable** to make the 51 states work, even after letting the code run for 45+ minutes, but I cant tell whats wrong.

I have the code currently **run and complete the 10 state problem** which it finds almost immediately, then run the 51 state problem and run.