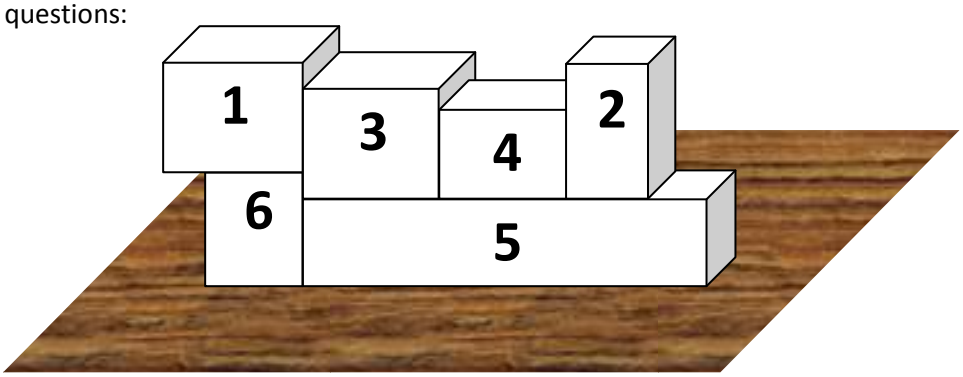
AI-Assignment#4 (CSP)

1) In this question, you will be solving a box-coloring problem. In this domain, there are 6 boxes stacking on each others. Each of the boxes must be colored in one color of three possible colors (Gold, Silver, and Bronze). The boxes must be colored in such a way that no adjacent boxes are the same color. Two boxes are considered to be adjacent if they touch along an edge. (Two boxes that touch only at a corner are not adjacent.) Here is the picture that you'll be using for all of the questions:



A) **Backtracking search**

Suppose we decide to use simple backtracking search to find a solution to this constraint satisfaction problem. The variable ordering heuristic we use is simply to instantiate the variables in numbered order. The color value ordering heuristic is to consider the color values in the order Gold, Silver, Bronze. You can use any reasonable shorthand to indicate the instantiations (e.g., "1=G" can mean box 1 is instantiated to the gold color).

(i) Show the complete search tree, circling the solution node, if one is found.
(ii) Show the final coloring, if one is found, on the picture above or on a copy of the picture.
(iii) How many variable instantiations (search steps for both successful and unsuccessful) are tried by this search method?

B) **Forward checking**

Now suppose we use forward checking to eliminate illegal values from the domains of un-instantiated variables. (Recall that in forward checking; only the constraints immediately connected to instantiated variables are checked.) Furthermore, suppose we use a variable ordering heuristic that chooses the variable with the fewest legal instantiations remaining to instantiate next. If more than one such variable exists, the one earlier in the numbered order is selected (for example, choose box 1 before box 3). The same color value ordering heuristic is used as in backtracking search (i.e., consider first gold, then silver, then bronze).

(i) Show the complete search tree for forward checking search. At each node, show the remaining legal values for the un-instantiated variables. For example, at the first node below the root, only box 1 will be colored, so you should indicate the legal values for variables 2, 3, 4, and 5. Continue until your search finds a solution or fails.
(ii) Show the final coloring, if one is found, on a copy of the picture above.
(iii) How many variable instantiations are tried by this search method?

C) **Solution spaces**

(i) How large is the search space for this problem? That is, how many different colorings, legal or illegal, are there for the blank picture shown above?
(ii) For this picture, how many different solutions (legal colorings) are there?

2) Representing and solving a CSP problem:

Constraints At The Zoo

Last month, five mothers brought their five kids to the zoo. It was a fun time for the kids. Some of the kids dared to touch animal fur and feed the food for some animals. Moreover, every kid found out that each of them had one kind of animals of their own favorite and one kind of hated animals. Surprisingly, all those animals were only five distinctive kinds of animals. In addition, an animal that a kid loved would be the animal that another kid hated, because each kid liked and disliked different kinds of animals. Additionally, in order to reward the kids who well behaved for the whole day, the mothers bought snacks for the kids—one kind for each kid. More clues are listed as follows…

1. **Julia** chose **candy**. **Mary** did not choose **apple**. Kid whose last name was **Procter** did not like **monkey**.
2. **Alan Small**'s favorite animal was not **seal**. **Beth** is the girl who did not choose **doughnut**.
3. No boys chose **doughnut**. One boy chose **corn-chip**. Another boy liked **monkey**. One who did not like **giraffe** chose **popcorn**.
4. The kid whose last name was **Brown** liked **lion**. **Beth** liked **seal**. **Mary**'s last name was not **Cook**.
5. **Tom**, whose last name was not **Brown** did not choose **apple**. The kid whose last name was **Macgregor** chose **doughnut**.
6. The girl who liked **elephant** did not like **seal**. The kid whose last name was **Cook** liked **monkey**. The animal **Alan** hated was not **giraffe**.

A) Define this problem formally as a CSP problem.

- ***Initial Domain***
- ***Set of variables***
- ***A domain of possible values***
- ***Set of constraints***

B) Using the provided information, ***your task is to determine each kid's first name and last name, their favorite and hated animals, and snack each kid chose***. Use the MRV heuristic and forward checking. Some of the constraints can be encoded directly in the initial domains. **Show your steps**.

	Person 1	Person 2	Person 3	Person 4	Person 5
First name	Alan	Tom	Julia	Mary	Beth
Last name	Procter, Small, Brown, Cook, Macgregor	Procter, Small, Brown, Cook, Macgregor	Procter, Small, Brown, Cook, Macgregor	Procter, Small, Brown, Cook, Macgregor	Procter, Small, Brown, Cook, Macgregor
Favorite animal	Monkey, Giraffe, Lion, Seal, Elephant	Monkey, Giraffe, Lion, Seal, Elephant	Monkey, Giraffe, Lion, Seal, Elephant	Monkey, Giraffe, Lion, Seal, Elephant	Monkey, Giraffe, Lion, Seal, Elephant
Hated animal	Monkey, Giraffe, Lion, Seal, Elephant	Monkey, Giraffe, Lion, Seal, Elephant	Monkey, Giraffe, Lion, Seal, Elephant	Monkey, Giraffe, Lion, Seal, Elephant	Monkey, Giraffe, Lion, Seal, Elephant
Snack	Candy, Caramel apple, Doughnut, Popcorn, Corn chip	Candy, Caramel apple, Doughnut, Popcorn, Corn chip	Candy, Caramel apple, Doughnut, Popcorn, Corn chip	Candy, Caramel apple, Doughnut, Popcorn, Corn chip	Candy, Caramel apple, Doughnut, Popcorn, Corn chip
Sex					

3) Consider the game of Sudoku 4x4 below:

		2	
	4		
		4	
	3		

The objective of this game is to fill a 4×4 grid with digits so that each column, each row, and each of the four 2×2 sub-grids that compose a big box containing all of the digits from 1 to 4. The puzzle initially provides a partially completed grid, which typically has a unique solution.

- ***Find a possible solution***. Please use any technique of CSP to solve it. Be sure to define this problem formally as a CSP problem and show all your works.