**Exercise 2: Constraints Satisfaction Problem Solving in Python**

**COMP-5313-FA-Artificial Intelligence**

Group 5

## Overview

The problem provides the requirements:

* Five houses in a row, each of them has different color, each of them has a man from different country.
* Each of the five men drink different beverage, smoke different brand of cigarettes, and keep different pets.

The clues offer logical relations, and the goal is to find who keeps the fish.

We assume this problem is set to ask us to have deeper understanding of CSPs in Lecture 4. So, we cope with python-constraint library according to Lecture 4.

## Problem Analysis

### Understanding of CSP

A Constraint Satisfaction Problem (CSP) is defined by a set of variables, each having a domain of possible values, and a set of constraints that limit which combinations of values are valid. Solving a CSP is to find an assignment of values to all variables such that all constraints are satisfied.

CSPs are typically solved using algorithms such as backtracking, combined with constraint propagation and consistency checking to cut off invalid partial assignments.

In this assignment, we will use the python-constraint library, which applies backtracking and consistency checking to find the valid assignment.

Next, we need to identify the variables, their domains, and the constraints described in the puzzle. Then model them in Python using a CSP framework to find a consistent assignment that satisfies all constraints.

### Variables & Domains in the problem

Each variable represents five houses (1 to 5)，then the domain of each is {1,2,3,4,5}

|  |  |
| --- | --- |
| **Category** | **Domain** |
| color | red, green, white, yellow, blue |
| country | Brit, Swede, Dane, Norwegian, German |
| drink | tea, coffee, milk, beer, water |
| cigarette | PallMall, Dunhill, Blends, Camel, Marlborough |
| pet | dog, birds, cats, horses, fish |

### Constrains

From the puzzle we have the constrains as follows:

1. The Brit lives in a red house.
2. The Swede keeps a dog.
3. The Dane drinks tea.
4. The green house is direct to the left of the white house.
5. The green house owner drinks coffee.
6. The person who smokes Pall Mall keeps birds.
7. The owner of the yellow house smokes Dunhill.
8. The man living in the house right in the center drinks milk.
9. The Norwegian lives in the first house.
10. The man who smokes Blends lives next to the one who keeps cats.
11. The man who keeps horses lives next to the man who smokes Dunhill.
12. The owner who smokes Camel drinks beer.
13. The German smokes Marlborough.
14. The Norwegian lives next to the blue house.
15. The man who smokes Blends has a neighbor who drinks water.

## Implementation

1. Library: python-constraint
2. Model each category (color, country, drink, cigarette, pet) as a set of variables, each having a domain of house {1 to 5}
3. All values in each category must be different ( using AllDifferentConstraint()).
4. Translate clues into lamda constraint functions.
5. The library automatically solve the problem with backtracking method.
6. The result is all the solutions that satisfy all the constraints. In this puzzle, there is only one solution.

The result is as follows:

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AI 生成的内容可能不正确。

We can see that the fish is in house 4, and the German lives in house4.

So, the answer is: **the German keeps the fish**.

**NOTE**: When doing the implementation, we found the description of the green house position was ambiguous. Thus, we also did the experiment to change the constraint into:

problem.addConstraint(lambda g, w: w - g >= 1, ("green", "white"))

Then we got 7 different solutions, which all satisfied the constraints.

For the uniqueness of the puzzle, we decided to keep the stricter constraint “being directly to the left of the white house”.

## Conclusion

Einstein’s Riddle is a typical CSP, as it requires assigning values to a set of variables according to the given clues, which can be translated into constraints directly.

Through this exercise, we deepened our understanding of the CSPs, and got familiar with the python tools (python-constraint).

## How to Run

.py file:

1. Make sure you have Python 3.10 or later installed.
2. Install libraries: pip install python-constraint
3. Then run the script: Group5\_Ex2.py

.jupyter file:

1. Launch Jupyter Notebook.
2. Open and run Group5\_Ex2.ipynb.