**Lab 08**

**Constraint Satisfaction Problems**

We have seen so many techniques like **Local search, Adversarial search** to solve different problems. The objective of every problem-solving technique is one, i.e., to find a solution to reach the goal. Although, in adversarial search and local search, there were no constraints on the agents while solving the problems and reaching to its solutions.

In this section, we will discuss another type of problem-solving technique known as Constraint satisfaction technique. By the name, it is understood that **constraint satisfaction means solving a problem under certain constraints or rules.**

Constraint satisfaction is a technique where a problem is solved when its values satisfy certain constraints or rules of the problem. Such type of technique leads to a deeper understanding of the problem structure as well as its complexity

**Components of CSP Problems**

Constraint satisfaction depends on three components, namely:

* X: It is a set of variables.
* D: It is a set of domains where the variables reside. There is a specific domain for each variable.
* C: It is a set of constraints which are followed by the set of variables.

In constraint satisfaction, domains are the spaces where the variables reside, following the problem specific constraints. These are the three main elements of a constraint satisfaction technique. The constraint value consists of a pair of {scope, rel}. The scope is a tuple of variables which participate in the constraint and rel is a relation which includes a list of values which the variables can take to satisfy the constraints of the problem.

Solving Constraint Satisfaction Problems

The requirements to solve a constraint satisfaction problem (CSP) is:

* A state-space
* The notion of the solution.

A state in state-space is defined by assigning values to some or all variables such as

{X1=v1, X2=v2, and so on…}.

An assignment of values to a variable can be done in three ways:

* Consistent or Legal Assignment: An assignment which does not violate any constraint or rule is called Consistent or legal assignment.
* Complete Assignment: An assignment where every variable is assigned with a value, and the solution to the CSP remains consistent. Such assignment is known as Complete assignment.
* Partial Assignment: An assignment which assigns values to some of the variables only. Such type of assignments are called Partial assignments.

Types of Domains in CSP

There are following two types of domains which are used by the variables :

* Discrete Domain: It is an infinite domain which can have one state for multiple variables. For example, a start state can be allocated infinite times for each variable.
* Finite Domain: It is a finite domain which can have continuous states describing one domain for one specific variable. It is also called a continuous domain.

Constraint Types in CSP

With respect to the variables, basically there are following types of constraints:

* Unary Constraints: It is the simplest type of constraints that restricts the value of a single variable.
* Binary Constraints: It is the constraint type which relates two variables. A value x2 will contain a value which lies between x1 and x3.
* Global Constraints: It is the constraint type which involves an arbitrary number of variables.

**The Australian map-coloring problem**

Imagine you have a map of Australia that you want to color by state/territory (which we’ll collectively call “regions”). No two adjacent regions should share a color. Can you color the regions with only three different colors?

**Given Data**

VARIABLES = ["Western Australia", "Northern Territory", "South Australia", "Queensland", "New South Wales", "Victoria", "Tasmania"]

DOMAINS = ["red", "green", "blue"]

CONSTRAINTS = [ ("Western Australia", "Northern Territory"), ("Western Australia", "South Australia"), ("South Australia", "Northern Territory"), ("Queensland", "Northern Territory"), ("Queensland", "South Australia"), ("Queensland", "New South Wales"), ("New South Wales", "South Australia"), ("Victoria", "South Australia"), ("Victoria", "New South Wales"), ("Victoria", "Tasmania")]

