Constraint Satisfaction Problems

Manuel Pita | May 2020

UNIVERSIDADE
LUSÓFONA

Today

- Discussion about the MidTerm test
- Modifications in the evaluation system
- Recap: Genetic Programming and Symbolic Regression
- Constraint Satisfaction Problems

MidTerm and Evaluation

- Discussion about the MidTerm test
- Theory: 25% Midterm + 25% Final exam
- Practise: 15% Midterm, 20% Interviews, 15% final exam

Genetic Programming and Symbolic Regression

- What do you remember?
- Discussion

Side Story: Digital Contact Tracing

A positive step? Or not?

Are all the claims made in this video true?

What is the European position on DCT? What about Portugal?

What other solutions could be ethically more convincing?

What problems do you foresee with DCT?

https://www.youtube.com/watch?v=WRalTWAFBY4

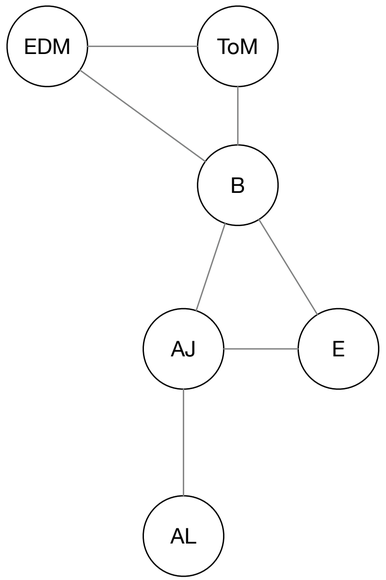
Constraint Satisfaction Problems

- Define the variables Xi
- Domains for each variable Di
- List of mathematical constraints C
- Example: Map colouring
- Variables {EDM, ToM, B, E, AJ, AL}
- Domains: all the same {Red, Yellow, Blue}
- Constraints: EDM ≠ ToM, EDM ≠ B, ToM ≠B, B≠E, B≠ AJ, E≠AJ, AJ ≠ AL
- Constraints can be Unary too. For example, imagine that people from Beira do not like the color red. In that case we would make the Beira Domain have only {Yellow, Blue}
- We want to find a solution

Constraint Satisfaction Problems

Search for consistency

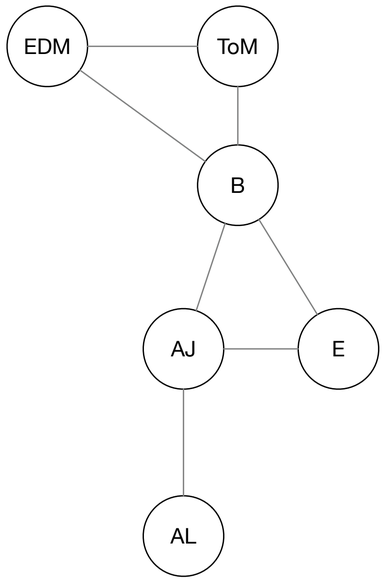
- To the right you will see the constraint graph for our example
- We want to ensure that the values we assign to each variable are consistent
- There is node consistency: ensuring variable’s unary constraints are satisfied
- There is arc consistency: ensuring variable’s binary constraints are satisfied



Constraint Satisfaction Problems

Constraint propagation

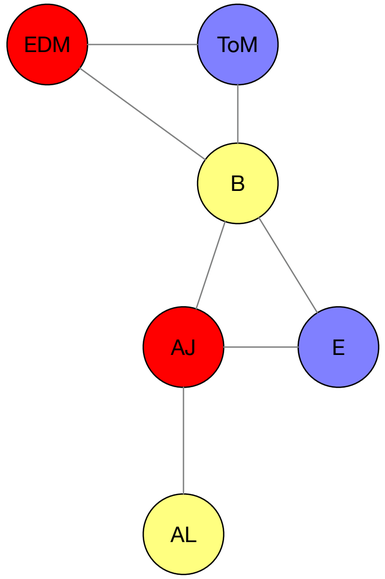
- The basic search dynamics is as follows
- Pick a variable, assign a value
- Propagate this assignment over the graph
- If there is inconsistency, backtrack
- Repeat until all domains have a value and there are no violations.



Constraint Satisfaction Problems

Constraint propagation

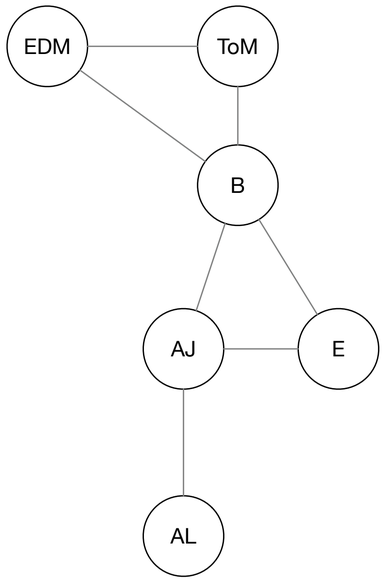
	EDM	ToM	B	AJ	E	AL
	{R,Y,B}	{R,Y,B}	{Y,B}	{R,Y,B}	{R,Y,B}	{R,Y,B}
EDM = R	**R**	{Y,B}	{Y,B}	{R,Y,B}	{R,Y,B}	{R,Y,B}
ToM = B	-	**B**	{Y}	{R,Y,B}	{R,Y,B}	{R,Y,B}
B must be Y	-	-	**Y**	{R,B}	{R,B}	{R,Y,B}
AJ = R				**R**	{B}	{R,Y,B}



Constraint Satisfaction Problems

Heuristics

- What variable to pick first?
  - Degree Heuristic (DH)
  - Max Constrained Variable (MCV)
- What value to pick first?
  - Least Constraining Value (LCV)



Constraint Satisfaction Problems

When to backtrack

- When propagation leaves no options in the domain of some variable
- When the options left force an assignment that is in violation of constraint
- Backtracking means selecting another assignment for the variable in a given iteration.

Constraint Satisfaction Problems

Cryptoarithmetic

```
   TWO
+  TWO
------
  FOUR
```

- Variables: {F,O,R,T,U,W}
- Domains {0-9}
- Constraints: AllDiff, and O+O = R, W+W = U, etc.

Constraint Satisfaction Problems

Cryptoarithmetic

```
   TWO
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- Variables: {F,O,R,T,U,W}
- Domains {0-9}
- Constraints: AllDiff, and O+O = R, W+W = U, etc.

R1: $O + O = R + 10 * C_1$
R2: $C_1 + W + W = U + 10 * C_2$
R3: $C_2 + T + T = O + 10 * C_3$
R4: $C_3 = F$