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Constraint Programming

# Section 1: Forward Checking

### Description of Code

In this python code, I created two class files using Object-Oriented Programming to program the CSP. The first file is called CSP.py which calls the instantiation function whilst FCSolver.py holds the necessary function used for forward checking to solve the n-queens problem. I used two main functions for the FCSolver.py one called FCBranchLeft inputs a queen (variable) and value (domain) and checks if the equality can be pruned. The FCBranchRight is used to check the opposite for when the queen and value are not equal.

I used a list instantiated in the CSP.py by the ‘set\_constraint’ procedure to create the constraints between two different queens, the revised method then works in FCSolver.py to check which domains still work referring to the list of constraints. On each branch attempt, I used the python library copy to take a screenshot of all the domains to redo each branch.

Output trace of 6 Queens

Left Branch now Q0=0

Revised domains:

Q0: [0, 1, 2, 3, 4, 5]

Q1: [2, 3, 4, 5]

Q2: [1, 3, 4, 5]

Q3: [1, 2, 4, 5]

Q4: [1, 2, 3, 5]

Q5: [1, 2, 3, 4]

Left Branch now Q1=2

Revised domains:

Q0: [0, 1, 2, 3, 4, 5]

Q1: [2, 3, 4, 5]

Q2: [1, 4, 5]

Q3: [1, 5]

Q4: [1, 3]

Q5: [1, 3, 4]

Left Branch now Q2=1

Revised domains:

Q0: [0, 1, 2, 3, 4, 5]

Q1: [2, 3, 4, 5]

Q2: [1, 4, 5]

Q3: [5]

Q4: [3]

Q5: [3, 4]

Left Branch now Q3=5

Revised domains:

Q0: [0, 1, 2, 3, 4, 5]

Q1: [2, 3, 4, 5]

Q2: [1, 4, 5]

Q3: [5]

Q4: [3]

Q5: [4]

Left Branch now Q4=3

Domain Wipeout

Right Branch now Q4!=3

Right Branch now Q3!=5

Right Branch now Q2!=1

Revised domains:

Q0: [0, 1, 2, 3, 4, 5]

Q1: [2, 3, 4, 5]

Q2: [4, 5]

Q3: [1]

Q4: [1, 3]

Q5: [1, 3, 4]

Left Branch now Q2=4

Revised domains:

Q0: [0, 1, 2, 3, 4, 5]

Q1: [2, 3, 4, 5]

Q2: [4, 5]

Q3: [1]

Q4: [1, 3]

Q5: [1, 3]

Left Branch now Q3=1

Domain Wipeout

Right Branch now Q3!=1

Right Branch now Q2!=4

Revised domains:

Q0: [0, 1, 2, 3, 4, 5]

Q1: [2, 3, 4, 5]

Q2: [5]

Q3: [1]

Q4: [1]

Q5: [1, 3, 4]

Left Branch now Q2=5

Revised domains:

Q0: [0, 1, 2, 3, 4, 5]

Q1: [2, 3, 4, 5]

Q2: [5]

Q3: [1]

Q4: [1]

Q5: [1, 3, 4]

Left Branch now Q3=1

Domain Wipeout

Right Branch now Q3!=1

Right Branch now Q2!=5

Right Branch now Q1!=2

Revised domains:

Q0: [0, 1, 2, 3, 4, 5]

Q1: [3, 4, 5]

Q2: [1, 3, 5]

Q3: [1, 2, 4, 5]

Q4: [1, 2, 3, 5]

Q5: [1, 2, 3, 4]

Left Branch now Q1=3

Revised domains:

Q0: [0, 1, 2, 3, 4, 5]

Q1: [3, 4, 5]

Q2: [1, 5]

Q3: [1, 2, 4]

Q4: [1, 2, 5]

Q5: [1, 2, 4]

Left Branch now Q2=1

Revised domains:

Q0: [0, 1, 2, 3, 4, 5]

Q1: [3, 4, 5]

Q2: [1, 5]

Q3: [2]

Q4: [2]

Q5: [2, 4]

Left Branch now Q3=2

Domain Wipeout

Right Branch now Q3!=2

Right Branch now Q2!=1

Revised domains:

Q0: [0, 1, 2, 3, 4, 5]

Q1: [3, 4, 5]

Q2: [5]

Q3: [1, 2]

Q4: [1, 2]

Q5: [1, 4]

Left Branch now Q2=5

Revised domains:

Q0: [0, 1, 2, 3, 4, 5]

Q1: [3, 4, 5]

Q2: [5]

Q3: [1, 2]

Q4: [1, 2]

Q5: [1, 4]

Left Branch now Q3=1

Domain Wipeout

Right Branch now Q3!=1

Domain Wipeout

Right Branch now Q2!=5

Right Branch now Q1!=3

Revised domains:

Q0: [0, 1, 2, 3, 4, 5]

Q1: [4, 5]

Q2: [1, 3]

Q3: [1, 2, 4, 5]

Q4: [1, 2, 3, 5]

Q5: [1, 2, 3, 4]

Left Branch now Q1=4

Revised domains:

Q0: [0, 1, 2, 3, 4, 5]

Q1: [4, 5]

Q2: [1, 3]

Q3: [1, 2, 5]

Q4: [1, 2, 3, 5]

Q5: [1, 2, 3]

Left Branch now Q2=1

Revised domains:

Q0: [0, 1, 2, 3, 4, 5]

Q1: [4, 5]

Q2: [1, 3]

Q3: [5]

Q4: [2]

Q5: [2, 3]

Left Branch now Q3=5

Revised domains:

Q0: [0, 1, 2, 3, 4, 5]

Q1: [4, 5]

Q2: [1, 3]

Q3: [5]

Q4: [2]

Q5: [2]

Left Branch now Q4=2

Domain Wipeout

Right Branch now Q4!=2

Right Branch now Q3!=5

Right Branch now Q2!=1

Revised domains:

Q0: [0, 1, 2, 3, 4, 5]

Q1: [4, 5]

Q2: [3]

Q3: [1, 5]

Q4: [2]

Q5: [1, 2]

Left Branch now Q2=3

Revised domains:

Q0: [0, 1, 2, 3, 4, 5]

Q1: [4, 5]

Q2: [3]

Q3: [1, 5]

Q4: [2]

Q5: [1, 2]

Left Branch now Q3=1

Revised domains:

Q0: [0, 1, 2, 3, 4, 5]

Q1: [4, 5]

Q2: [3]

Q3: [1, 5]

Q4: [2]

Q5: [2]

Left Branch now Q4=2

Domain Wipeout

Right Branch now Q4!=2

Right Branch now Q3!=1

Revised domains:

Q0: [0, 1, 2, 3, 4, 5]

Q1: [4, 5]

Q2: [3]

Q3: [5]

Q4: [2]

Q5: [1, 2]

Left Branch now Q3=5

Revised domains:

Q0: [0, 1, 2, 3, 4, 5]

Q1: [4, 5]

Q2: [3]

Q3: [5]

Q4: [2]

Q5: [1, 2]

Left Branch now Q4=2

Domain Wipeout

Right Branch now Q4!=2

Right Branch now Q3!=5

Right Branch now Q2!=3

Right Branch now Q1!=4

Revised domains:

Q0: [0, 1, 2, 3, 4, 5]

Q1: [5]

Q2: [1, 3]

Q3: [1, 2, 4]

Q4: [1, 3]

Q5: [2, 3, 4]

Left Branch now Q1=5

Revised domains:

Q0: [0, 1, 2, 3, 4, 5]

Q1: [5]

Q2: [1, 3]

Q3: [1, 2, 4]

Q4: [1, 3]

Q5: [2, 3, 4]

Left Branch now Q2=1

Domain Wipeout

Right Branch now Q2!=1

Domain Wipeout

Right Branch now Q1!=5

Right Branch now Q0!=0

Revised domains:

Q0: [1, 2, 3, 4, 5]

Q1: [0, 1, 2, 3, 4, 5]

Q2: [0, 1, 2, 3, 4, 5]

Q3: [0, 1, 2, 3, 4, 5]

Q4: [0, 1, 2, 3, 4, 5]

Q5: [0, 1, 2, 3, 4, 5]

Left Branch now Q0=1

Revised domains:

Q0: [1, 2, 3, 4, 5]

Q1: [0, 3, 4, 5]

Q2: [0, 2, 4, 5]

Q3: [0, 2, 3, 5]

Q4: [0, 2, 3, 4]

Q5: [0, 2, 3, 4, 5]

Left Branch now Q1=0

Revised domains:

Q0: [1, 2, 3, 4, 5]

Q1: [0, 3, 4, 5]

Q2: [2, 4, 5]

Q3: [2, 3, 5]

Q4: [2, 3, 4]

Q5: [2, 3, 4, 5]

Left Branch now Q2=2

Revised domains:

Q0: [1, 2, 3, 4, 5]

Q1: [0, 3, 4, 5]

Q2: [2, 4, 5]

Q3: [5]

Q4: [3]

Q5: [3, 4]

Left Branch now Q3=5

Revised domains:

Q0: [1, 2, 3, 4, 5]

Q1: [0, 3, 4, 5]

Q2: [2, 4, 5]

Q3: [5]

Q4: [3]

Q5: [4]

Left Branch now Q4=3

Domain Wipeout

Right Branch now Q4!=3

Right Branch now Q3!=5

Right Branch now Q2!=2

Revised domains:

Q0: [1, 2, 3, 4, 5]

Q1: [0, 3, 4, 5]

Q2: [4, 5]

Q3: [2, 3]

Q4: [2, 3, 4]

Q5: [2, 3, 4, 5]

Left Branch now Q2=4

Revised domains:

Q0: [1, 2, 3, 4, 5]

Q1: [0, 3, 4, 5]

Q2: [4, 5]

Q3: [2, 3]

Q4: [2, 3]

Q5: [2, 3, 5]

Left Branch now Q3=2

Domain Wipeout

Right Branch now Q3!=2

Domain Wipeout

Right Branch now Q2!=4

Revised domains:

Q0: [1, 2, 3, 4, 5]

Q1: [0, 3, 4, 5]

Q2: [5]

Q3: [2, 3]

Q4: [2, 4]

Q5: [3, 4]

Left Branch now Q2=5

Revised domains:

Q0: [1, 2, 3, 4, 5]

Q1: [0, 3, 4, 5]

Q2: [5]

Q3: [2, 3]

Q4: [2, 4]

Q5: [3, 4]

Left Branch now Q3=2

Revised domains:

Q0: [1, 2, 3, 4, 5]

Q1: [0, 3, 4, 5]

Q2: [5]

Q3: [2, 3]

Q4: [4]

Q5: [3, 4]

Left Branch now Q4=4

Domain Wipeout

Right Branch now Q4!=4

Right Branch now Q3!=2

Domain Wipeout

Right Branch now Q2!=5

Right Branch now Q1!=0

Revised domains:

Q0: [1, 2, 3, 4, 5]

Q1: [3, 4, 5]

Q2: [0, 2, 5]

Q3: [0, 2, 3, 5]

Q4: [0, 2, 3, 4]

Q5: [0, 2, 3, 4, 5]

Left Branch now Q1=3

Revised domains:

Q0: [1, 2, 3, 4, 5]

Q1: [3, 4, 5]

Q2: [0, 2, 5]

Q3: [0, 2]

Q4: [0, 2, 4]

Q5: [0, 2, 4, 5]

Left Branch now Q2=0

Revised domains:

Q0: [1, 2, 3, 4, 5]

Q1: [3, 4, 5]

Q2: [0, 2, 5]

Q3: [2]

Q4: [2, 4]

Q5: [2, 4, 5]

Left Branch now Q3=2

Revised domains:

Q0: [1, 2, 3, 4, 5]

Q1: [3, 4, 5]

Q2: [0, 2, 5]

Q3: [2]

Q4: [4]

Q5: [5]

Left Branch now Q4=4

Domain Wipeout

Right Branch now Q4!=4

Right Branch now Q3!=2

Right Branch now Q2!=0

Revised domains:

Q0: [1, 2, 3, 4, 5]

Q1: [3, 4, 5]

Q2: [2, 5]

Q3: [0, 2]

Q4: [0, 2, 4]

Q5: [0, 4]

Left Branch now Q2=2

Revised domains:

Q0: [1, 2, 3, 4, 5]

Q1: [3, 4, 5]

Q2: [2, 5]

Q3: [0]

Q4: [0]

Q5: [0, 4]

Left Branch now Q3=0

Domain Wipeout

Right Branch now Q3!=0

Right Branch now Q2!=2

Revised domains:

Q0: [1, 2, 3, 4, 5]

Q1: [3, 4, 5]

Q2: [5]

Q3: [0, 2]

Q4: [0, 2, 4]

Q5: [0, 4]

Left Branch now Q2=5

Revised domains:

Q0: [1, 2, 3, 4, 5]

Q1: [3, 4, 5]

Q2: [5]

Q3: [0, 2]

Q4: [0, 2, 4]

Q5: [0, 4]

Left Branch now Q3=0

Revised domains:

Q0: [1, 2, 3, 4, 5]

Q1: [3, 4, 5]

Q2: [5]

Q3: [0, 2]

Q4: [2, 4]

Q5: [4]

Left Branch now Q4=2

Revised domains:

Q0: [1, 2, 3, 4, 5]

Q1: [3, 4, 5]

Q2: [5]

Q3: [0, 2]

Q4: [2, 4]

Q5: [4]

Left Branch now Q5=4

Revised domains:

Q0: [1, 2, 3, 4, 5]

Q1: [3, 4, 5]

Q2: [5]

Q3: [0, 2]

Q4: [2, 4]

Q5: [4]

Our Solution Assignments : {0: 1, 1: 3, 2: 5, 3: 0, 4: 2, 5: 4}

# Section 2: Modelling the Task Allocation Problem

Evaluation of Instance1.param

From the Allocation table, we have received an allocation where all constraints are met with each task allocated to one person and for each person, the duration of the task allocated to them does not exceed the deadline. However, coming to the objective function the cost shows a value whereas the best and optimal value would be 0.

Evaluation of Instance2.param

From this Allocation table, found that all constraints are met. With the objective function, the total objective function comes to 6 where the optimal solution should be the square mean error of 36.