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Mathematics Department, University of Padova

Number Mind Game

Knowledge and Data Mining Project

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Chapter I

Problem and Method

Number Mind Game

- Initial Theory
  - first of all, we considered a number for every number in every position

```
def digit(n,r):
    return n*numdigit + r + 1
```

  - The first constraint in the problem is :

#each position should have at least a number

$$\bigwedge_{r=1}^{number\ of\ digit} \bigvee_{n=0}^{9} digit(n,r)$$

```
1 for n in range(10):
2   for r in range(numdigit):
3     print("digit({},{})------->{}".format(n,r,digit(n,r)))
```

```
digit(0,0)------->1
digit(0,1)------->2
digit(0,2)------->3
digit(0,3)------->4
digit(0,4)------->5
digit(0,5)------->6
digit(0,6)------->7
digit(1,0)------->8
digit(1,1)------->9
digit(1,2)------->10
digit(1,3)------->11
digit(1,4)------->12
digit(1,5)------->13
digit(1,6)------->14
digit(2,0)------->15
digit(2,1)------->16
digit(2,2)------->17
digit(2,3)------->18
digit(2,4)------->19
digit(2,5)------->20
digit(2,6)------->21
digit(3,0)------->22
digit(3,1)------->23
digit(3,2)------->24
digit(3,3)------->25
digit(3,4)------->26
digit(3,5)------->27
digit(3,6)------->28
digit(4,0)------->29
digit(4,1)------->30
digit(4,2)------->31
digit(4,3)------->32
digit(4,4)------->33
digit(4,5)------->34
digit(4,6)------->35
digit(5,0)------->36
```

- Initial Theory

  - The second constraint in the problem is :

#A position can not have two value

$$\bigwedge_{r=1}^{number\ of\ digit} \bigwedge_{n=0}^{9} \bigwedge_{n \neq n', n'=0}^{9} digit(n, r) \rightarrow \neg digit(n', r)$$

- Updating Theory

  - If the number of the correct answer is zero:

#just add negation of the recent guess to the model

```
if num_correct == 0:

  for x in guess_c:
    num.add_clause([-x])
```

  - If the number of the correct answer is equal to the length of the initial guess:

#Guess is found

- Updating Theory

  - If the number of the correct answer is not zero and less than the length of the initial guess :

#Use exactly K propositional variables is true:

$$\bigwedge_{\substack{I\subseteq[n]\\|I|=n-k+1}} \bigvee x_i \quad \bigwedge_{\substack{I\subseteq[n]\\|I|=k+1}} \bigvee_{i\in I} \neg x_i$$

```
else:
  cnf_least = list(itertools.combinations(guess_c,len(guess_c) - int(num_correct) + 1))
  guess_neg = [ -x for x in guess_c]
  cnf_most = list(itertools.combinations(guess_neg, 1 + int(num_correct)))
  for x,y in zip(cnf_least, cnf_most):
    num.add_clause(list(x))
    num.add_clause(list(y))
```

Chapter II

Solving Procedure and Functions

Number Mind Game

Solving Procedure

- Generating the secret code:

```
1 numdigit = 12
2 #initial guess
3
4 secret_code = random_with_N_digits(numdigit)
5 print ("The secret code is :",secret_code)
6 code_c = num2CNFcode(secret_code,numdigit)
7 print ("The secret code is :",code_c)
```

```
The secret code is : 306146929874
The secret code is : [37, 2, 75, 16, 53, 78, 115, 32, 117, 106, 95, 60]
```

```
1 def random_with_N_digits(n):
2     range_start = 10**(n-1)
3     range_end = (10**n)-1
4     return randint(range_start, range_end)
5
```

```
def num2CNFcode(num,numdigit):

  CNFcode = [0] * numdigit
  for x in range(numdigit):
    CNFcode[numdigit - x -1]= digit(int(num%10), numdigit - x -1)
    num=int(num/10)
  return CNFcode
```

Solving Procedure

- Generating an initial guess:

```
 9
10 initial_guess = int (''.join(str(int(i)) for i in [8] *numdigit))
11 print ("initial guess is :",initial_guess)
12 guess_c = num2CNFcode(initial_guess,numdigit)
```

- Initializing SAT solver and adding general constraints.

```
14 clauses=[]
15 num = Minisat22()
16 #each position should have at least a number
17 for r in range(numdigit):
18   num.add_clause([digit(n,r) for n in range(10)])
19 #A position can not have two value
20 for r in range(numdigit):
21   for n in range(10):
22     for n1 in range(10):
23       if n!=n1:
24         num.add_clause([-digit(n,r),-digit(n1,r)])
25
```

Solving Procedure

- Using a WHILE loop to find the solutions.
- First of all, I will check the number of coincidences of guess and secret code:

```
STOP = False

while STOP==False :
  # find the number of correct digit
  num_correct= 0
  for i in guess_c:
    if i in code_c:
      num_correct = num_correct+1
  if num_correct==numdigit:
    break
  print("Method's guess is : {}, {} correct".format(decodify(guess_c),num_correct))
```

Solving Procedure

- Updating the SAT solver model and finding new guess:

```
39  if num_correct == 0:
40    for x in guess_c:
41      num.add_clause([-x])
42  elif num_correct == len(guess_c):
43    STOP=True
44  else:
45    cnf_least = list(itertools.combinations(guess_c,len(guess_c) - int(num_correct) + 1))
46    guess_neg = [ -x for x in guess_c]
47    cnf_most = list(itertools.combinations(guess_neg, 1 + int(num_correct)))
48    for x,y in zip(cnf_least, cnf_most):
49      num.add_clause(list(x))
50      num.add_clause(list(y))
51
52  result_flag= num.solve()
53  s=num
54  for m in s.enum_models():
55    m_positive = [x for x in m if x>0 ]
56    if len(m_positive) >= len(guess_c):
57      new_guess= m_positive[:len(guess_c)]
58      break
59  guess_c = new_guess
```

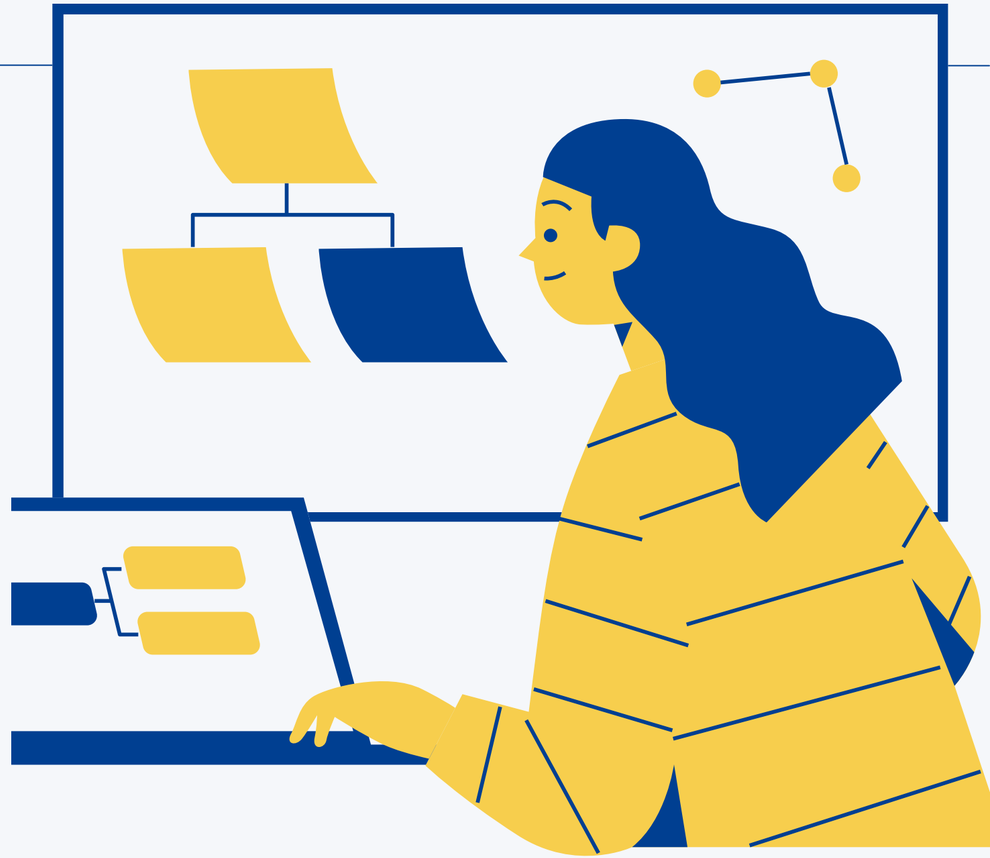
Chapter III

Results

Number Mind Game

- Average running time for 5 times

Length	Time (ms)	Length	Time(mS)
4	8.6	13	124.6
5	11.4	14	115.8
6	17.6	15	147.4
7	14	16	941.4
8	19.6	17	1857.8
9	19.2		
10	31		
11	41.6		
12	60.6		



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Thank you for listening

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