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Lab - 3

Aim - Implementation of constraint satisfaction problem - Cryptarithmetic problem (SEND + MORE = MONEY)

Problem Formulation

Given an expression where two words add to give a third word, assign some unique digit (0-9) to each letter where same letters cannot be assigned to different digit.

Display the possible mappings to each of the letters S, E, N, D, M, O, R and Y

Initial state

- D = ?, E = ?, Y = ?, N = ?, R = ?, O = ?, S = ?, M = ?
- C_1 = ?, C_2 = ?, C_3 = ?
- C_1, C_2, C_3 stands for carry variable respectively.

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Goal state

The digit to the letters must be assigned in such a manner so that sum is satisfied.
Various possible goal state is obtained.
One of the goal state is:

- D=7, E=5, Y=2, N=6, R=8, O=0, S=9, M=1
- $C_1=1, C_2=1, C_3=0$

Problem solving

- Starting from left hand side, the terms are S and M. Assign a digit which could give a satisfactory result. lets assign S=9, M=1

$$\begin{array}{r} S \\ +M \\ \hline MO \end{array} \rightarrow \begin{array}{r} 9 \\ +1 \\ \hline 10 \end{array}$$

we get O as O

- Moving ahead we get the next terms E and O to get N as its result.

Considering E=5

$$\begin{array}{r} E \\ +O \\ \hline N \end{array} \not\rightarrow \begin{array}{r} 5 \\ +O \\ \hline 5 \end{array}$$

This is not possible as E and N cannot be assigned to same digit.

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we assume that C_2 (carry) = 1

C_2 (carry)	(1)
F	5
+ O	+ 0
N	6

we get N as 6

- Further adding next two terms N and R

N	6	
+ R	+ 8	as F is already assigned value 5
F	14	

we consider $C_3 = 1$

N	6	we get R = 8
+ R	+ 8	
E	15	

- On adding last two terms 1 carry must be produced

D	7
+ E	+ 5
Y	12

- Keeping all constraints in mind the final state is

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	$C_3(0)$	$C_2(1)$	$C_1(1)$	
	S(9)	E(5)	N(6)	D(7)
+	M(1)	O(0)	R(8)	E(5)
M(1)	O(0)	N(6)	E(5)	Y(2)

S	9
E	5
N	6
D	7
M	1
O	0
R	8
Y	2

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ARTIFICIAL INTELLIGENCE LAB

LAB: 3

Implementation of Constraint Satisfaction Problems

(cryptarithmetic problem- send+more=money)

Algorithm:

Step 1: Start
Step 2: Accept a expression 'SEND+MORE=MONEY'
Step 3: Extract the words SEND, MORE and MONEY.
Step 4: Permute for different combination of values for S,E,N,D,M,O,R,Y.
Step5: Check if the sum of the left value i.e, SEND+MORE is equal to the right sum i.e, MONEY or not. If the sum value matches print the mapping.
Step 6: Continue for other permutations as well.
Step 7: Stop.

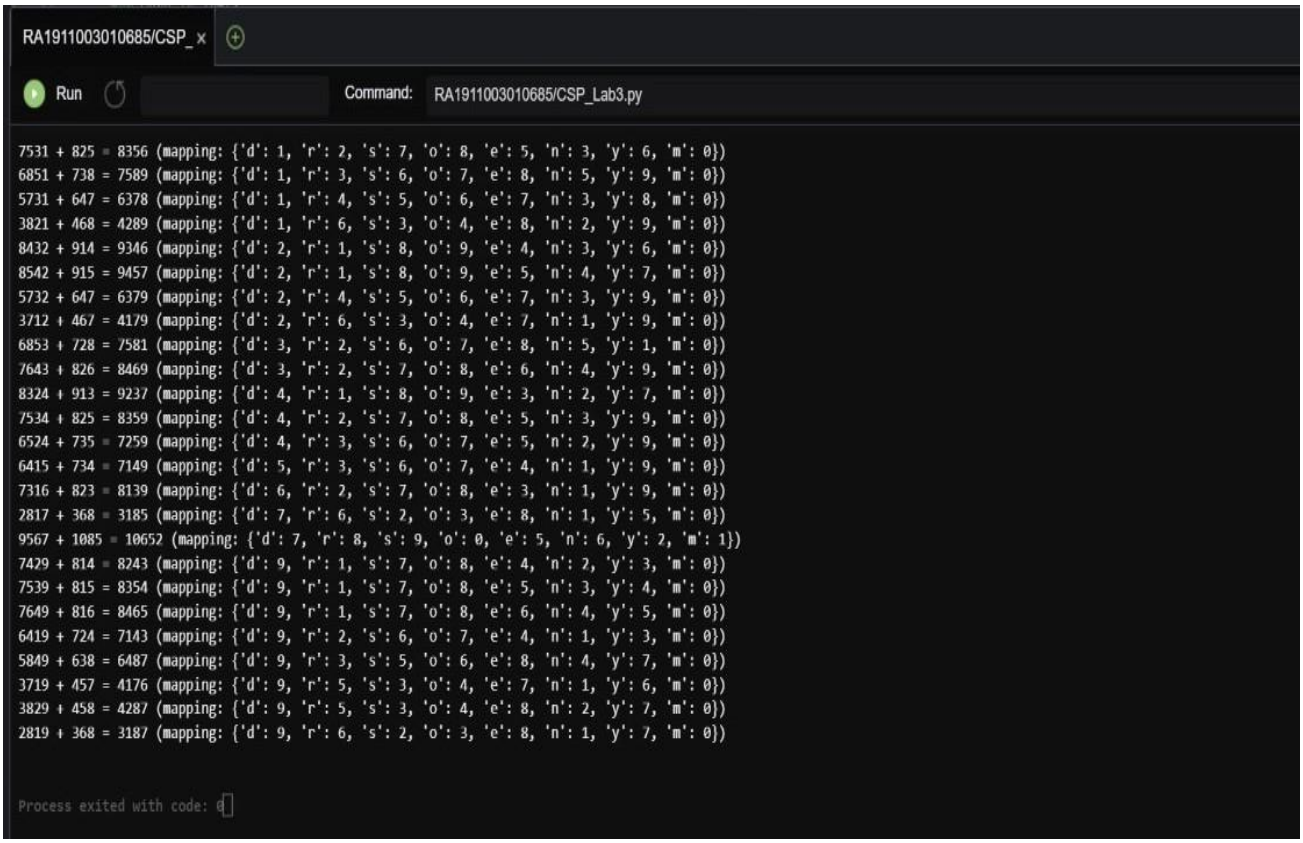
Source code:

```
import itertools

def get_value(word, substitution):
    s = 0
    factor = 1
    for letter in reversed(word):
        s += factor * substitution[letter]
```

```
        factor *= 10
    return s
def solve2(equation):
    left, right = equation.lower().replace(' ', '').split('=')
    left = left.split('+')
    letters = set(right)
    for word in left:
        for letter in word:
            letters.add(letter)
    letters = list(letters)
    digits = range(10)
    for perm in itertools.permutations(digits, len(letters)):
        sol = dict(zip(letters, perm))
        if sum(get_value(word, sol) for word in left) == get_value(right, sol):
            print(' + '.join(str(get_value(word, sol)) for word in left) + " = {}
(mapping: {})".format(get_value(right, sol), sol))
if__name__== '__main__':
    solve2('SEND + MORE = MONEY')
```

Output:



Result:

Hence, the implementation of the Cryptarithmetic Problem is done successfully.