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Experiment No. : 3

Date: 07/09/2022

Title : Playfair Cipher Implementation

Problem Definition : Implement Playfair cipher and illustrate encoding and decoding process on user entered sentence.

Prerequisite :
The Playfair cipher was the first practical digraph substitution cipher. The scheme was invented in 1854 by Charles Wheatstone but was named after Lord Playfair who promoted the use of the cipher.
In playfair cipher, unlike traditional cipher, we encrypt a pair of alphabets(digraphs) instead of a single alphabet.
It was used for tactical purposes by British forces in the Second Boer War and in World War I and for the same purpose by the Australians during World War II. This was because Playfair is reasonably fast to use and requires no special equipment.

Theory :
A playfair cipher works like this.

For the **encryption** process let us consider the following example:

Key : monarchy Plaintext : instruments

The Algorithm consists of 2 steps:

1. Generate the key Square(5×5):

The key square is a 5×5 grid of alphabets that acts as the key for encrypting the plaintext. Each of the 25 alphabets must be unique and one letter of the alphabet (usually J) is omitted from the table (as the table can hold only 25 alphabets). If the plaintext contains J, then it is replaced by I.

2. Algorithm to encrypt the plain text:

The plaintext is split into pairs of two letters (digraphs). If there is an odd number of letters, a Z is added to the last letter. For example:

PlainText: "instruments"
After Split: 'in' 'st' 'ru' 'me' 'nt' 'sz'

1. Pair cannot be made with the same letter. Break the letter in single andadd a bogus letter to the previous letter
2. If the letter is standing alone in the process of pairing, then add an extrabogus letter with the alone letter

Rules for Encryption:

- If both the letters are in the same column: Take the letter below each one (going back to the top if at the bottom).
- If both the letters are in the same row: Take the letter to the right of each one (going back to the leftmost if at the rightmost position).
- If neither of the above rules is true: Form a rectangle with the two letters and take the letters on the horizontal opposite corner of the rectangle.

Plain Text: "instrumentsz" Encrypted Text:

gatlmzclrqtx

Encryption:

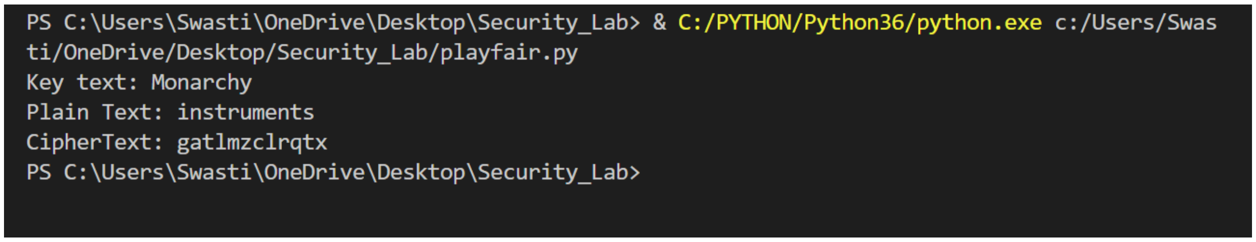
i -> g
n -> a s -
> t t -> l
r -> m u ->
z
m -
> ce -> l
n -
> rt -> q s
-> t z -> x

Procedure/ Algorithm :

```
# Python program to implement Playfair Cipher

# Function to convert the string to lowercase


def toLowerCase(text):
    return text.lower()

# Function to remove all spaces in a string


def removeSpaces(text):
    newText = ""
    for i in text:
        if i == " ":
            continue
        else:
            newText = newText + i
    return newText

# Function to group 2 elements of a string
# as a list element


def Diagraph(text):
    Diagraph = []
    group = 0
    for i in range(2, len(text), 2):
        Diagraph.append(text[group:i])

        group = i
    Diagraph.append(text[group:])
    return Diagraph

# Function to fill a letter in a string element
# If 2 letters in the same string matches


def FillerLetter(text):
    k = len(text)
    if k % 2 == 0:
        for i in range(0, k, 2):
            if text[i] == text[i+1]:
                new_word = text[0:i+1] + str('x') + text[i+1:]
                new_word = FillerLetter(new_word)
                break
            else:
                new_word = text
    else:
        for i in range(0, k-1, 2):
            if text[i] == text[i+1]:
                new_word = text[0:i+1] + str('x') + text[i+1:]
                new_word = FillerLetter(new_word)
                break
            else:
                new_word = text
    return new_word


list1 = ['a', 'b', 'c', 'd', 'e', 'f', 'g', 'h', 'i', 'k', 'l', 'm',
        'n', 'o', 'p', 'q', 'r', 's', 't', 'u', 'v', 'w', 'x', 'y', 'z']
```

```
# Function to generate the 5x5 key square matrix


def generateKeyTable(word, list1):
    key_letters = []
    for i in word:
        if i not in key_letters:
            key_letters.append(i)

    compElements = []
    for i in key_letters:
        if i not in compElements:
            compElements.append(i)
    for i in list1:
        if i not in compElements:
            compElements.append(i)

    matrix = []
    while compElements != []:
        matrix.append(compElements[:5])
        compElements = compElements[5:]

    return matrix


def search(mat, element):
    for i in range(5):
        for j in range(5):
            if(mat[i][j] == element):
                return i, j


def encrypt_RowRule(matr, e1r, e1c, e2r, e2c):
    char1 = ''
    if e1c == 4:
        char1 = matr[e1r][0]
    else:
        char1 = matr[e1r][e1c+1]

    char2 = ''
    if e2c == 4:
        char2 = matr[e2r][0]
    else:
        char2 = matr[e2r][e2c+1]
    return char1, char2


def encrypt_ColumnRule(matr, e1r, e1c, e2r, e2c):
    char1 = ''
    if e1r == 4:
        char1 = matr[0][e1c]
    else:
        char1 = matr[e1r+1][e1c]

    char2 = ''
    if e2r == 4:
        char2 = matr[0][e2c]
    else:
        char2 = matr[e2r+1][e2c]

    return char1, char2


def encrypt_RectangleRule(matr, e1r, e1c, e2r, e2c):
    char1 = ''
    char1 = matr[e1r][e2c]

    char2 = ''
    char2 = matr[e2r][e1c]

    return char1, char2


def encryptByPlayfairCipher(Matrix, plainList):
    CipherText = []
    for i in range(0, len(plainList)):
        c1 = 0
        c2 = 0
        ele1_x, ele1_y = search(Matrix, plainList[i][0])
        ele2_x, ele2_y = search(Matrix, plainList[i][1])

        if ele1_x == ele2_x:
            c1, c2 = encrypt_RowRule(Matrix, ele1_x, ele1_y, ele2_x, ele2_y)
            # Get 2 letter cipherText
        elif ele1_y == ele2_y:
            c1, c2 = encrypt_ColumnRule(Matrix, ele1_x, ele1_y, ele2_x, ele2_y)
        else:
            c1, c2 = encrypt_RectangleRule(
                Matrix, ele1_x, ele1_y, ele2_x, ele2_y)

        cipher = c1 + c2
        CipherText.append(cipher)
    return CipherText


text_Plain = 'instruments'
text_Plain = removeSpaces(toLowerCase(text_Plain))
PlainTextList = Diagraph(FillerLetter(text_Plain))
if len(PlainTextList[-1]) != 2:
    PlainTextList[-1] = PlainTextList[-1]+'z'

key = "Monarchy"
print("Key text:", key)
key = toLowerCase(key)
Matrix = generateKeyTable(key, list1)

print("Plain Text:", text_Plain)
CipherList = encryptByPlayfairCipher(Matrix, PlainTextList)

CipherText = ""
for i in CipherList:
    CipherText += i
print("CipherText:", CipherText)
```

Results:



```
PS C:\Users\Swasti\OneDrive\Desktop\Security_Lab> & C:/PYTHON/Python36/python.exe c:/Users/Swas
ti/OneDrive/Desktop/Security_Lab/playfair.py
Key text: Monarchy
Plain Text: instruments
CipherText: gatlmzclrqtx
PS C:\Users\Swasti\OneDrive\Desktop\Security_Lab>
```

References :

1) https://www.educba.com/types-of-cipher/
2) https://justcryptography.com/playfair-implementation/