Information_theory_project_202100432

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1 Information Theory Project Part 1

Saifelden Mohamed Ismail - 202100432

1.0.1 requirement 1

Calculating probabilities

[289]:
```
import string
import numpy as np
file_object = open("Test_text_file.txt")
file_raw=file_object.read();
symbols=string.ascii_lowercase+"().,/- "
symbols_probabilities=dict(zip(list(symbols),[0]*len(symbols)))
file_length=len(file_raw)

for i in range(file_length):
    symbols_probabilities[file_raw[i]]+=1*(1/file_length)

symbols_probabilities
```

[289]:
```
{'a': 0.07193732193732202,
 'b': 0.012108262108262113,
 'c': 0.026353276353276337,
 'd': 0.0455840455840456,
 'e': 0.10398860398860417,
 'f': 0.013532763532763538,
 'g': 0.01424501424501425,
 'h': 0.022079772079772072,
 'i': 0.0605413105413106,
 'j': 0.0007122507122507123,
 'k': 0.0007122507122507123,
 'l': 0.04202279202279203,
 'm': 0.02136752136752136,
 'n': 0.06410256410256417,
 'o': 0.06267806267806274,
 'p': 0.03703703703703703,
 'q': 0.0007122507122507123,
 'r': 0.05982905982905989,
```

```
 's': 0.05626780626780631,
 't': 0.07193732193732202,
 'u': 0.018518518518518517,
 'v': 0.009259259259259262,
 'w': 0.007834757834757837,
 'x': 0.004985754985754985,
 'y': 0.00641025641025641,
 'z': 0.002136752136752137,
 '(': 0.002136752136752137,
 ')': 0.002136752136752137,
 '.': 0.004273504273504274,
 ',': 0.007834757834757837,
 '/': 0.0007122507122507123,
 '-': 0.011396011396011,
 ' ': 0.1346153846153847}
```

1.0.2 Requirement 2

Calculating Entropy

[290]:
```python
from math import log2
Entropy = sum([ i*-log2(i) if i!=0 else 0 for i in symbols_probabilities.
 ↪values()])
print(Entropy, "bits/symbol")
```

```
4.257010564738072 bits/symbol
```

1.0.3 Requirement 3

Fixed Length Code Calculation

[291]:
```python
fixed_length_bits_per_symbol=round(log2(len(symbols)))
fixed_length_efficiency= 6*sum([*symbols_probabilities.values()])
print(fixed_length_efficiency, "bits/symbol")
```

```
6.0000000000000036 bits/symbol
```

1.0.4 Requirement 4

Huffman Encoding function

[292]:
```python
import bisect


class Node:
    def __init__(self,left=None,right=None):
        self.left=left
        self.right=right
        if self.left!=None and self.right !=None :
            self.value=self.calculate_value()
    def calculate_value(self):
```

```python
        left_value=self.left.value if isinstance(self.left, Node) else self.left[1]
        right_value=self.right.value if isinstance(self.right, Node) else self.right[1]
        return left_value +right_value

class encoder:
    def calculate_probabilities(self):
        file_object = open(self.file_name)
        file_raw=file_object.read();
        self.file_raw=file_raw
        self.symbols=list(set(file_raw))
        number_of_symbols=len(self.symbols)
        symbols_probabilities=[0]*number_of_symbols
        file_length=len(file_raw)
        for i in range(file_length):
            symbols_probabilities[self.symbols.index(file_raw[i])]+=(1/file_length)

        symbols_probabilities_set= list(zip(self.symbols,symbols_probabilities))
        self.symbols_probabilities=sorted(symbols_probabilities_set, key= lambda x: x[1] ,reverse=True)
    def generate_encoded_message(self):
        self.encoded_message=""
        for i in self.file_raw:
            self.encoded_message+=self.encoding[i]

    def generate_encoding(self,node=None,path="", leaves={}):
        if node is None:
            node= self.encoding_tree
        if not isinstance(node,Node):
            leaves[node[0]]=path
            return leaves
        self.generate_encoding(node.left,path+"0",leaves)
        self.generate_encoding(node.right,path+"1",leaves)
        return leaves



class huffman_encoder(encoder):
    def __init__(self,file_name,file_name_output):
        self.file_name=file_name
        super().calculate_probabilities()
        self.generate_huffman_tree()
        self.encoding=super().generate_encoding()
        super().generate_encoded_message()
```

```
        file_output=open(file_name_output,"w")
        file_output.write(self.encoded_message)
        file_output.close()
    def generate_huffman_tree(self):
        tree_list=self.symbols_probabilities
        tree_list= sorted(tree_list, key=lambda x: x.value if isinstance(x,␣
↪Node) else x[1])
        while(len(tree_list)>1):
            new_value=Node(tree_list.pop(0),tree_list.pop(0))
            bisect.insort(tree_list,new_value, key=lambda x:x.value if␣
↪isinstance(x,Node) else x[1] )
        self.encoding_tree=tree_list[0]
```

[293]:
```
from pandas import DataFrame as df
encoded_file=huffman_encoder("Test_text_file.txt","Test_text_file.zip")
table1=df({"Symbols":encoded_file.encoding.values(),"Encoding":encoded_file.
↪encoding.keys()})
huffman_code=encoded_file.encoding.values()
table1
```

[293]:

	Symbols	Encoding
0	0000	d
1	000100	-
2	000101	b
3	00011	c
4	001	e
5	0100	s
6	010100	f
7	0101010	y
8	0101011	w
9	010110	g
10	0101110	,
11	01011110	.
12	010111110	)
13	010111111	(
14	0110	r
15	0111	i
16	1000	o
17	1001	n
18	101	
19	1100	a
20	1101	t
21	11100	p

```
22       111010        u
23      1110110        v
24     11101110        x
25    111011110        z
26  11101111100        /
27  11101111101        k
28  11101111110        q
29  11101111111        j
30        11110        l
31       111110        m
32       111111        h
```

1.0.5 REQUIREMENT 5

Huffman Decoding Function

[294]:
```python
class decoder:
    def __init__(self,encoding_tree,file_input_name,file_output_name):
        self.encoding_tree=encoding_tree
        self.decode(file_input_name)
        self.file=open(file_output_name,"w")
        self.file.write(self.decoded_output)
        self.file.close()
    def decode(self,file_input_name):
        file_object = open(file_input_name)
        file_input_raw=file_object.read();
        self.file_input_raw=file_input_raw

        navigation_node=self.encoding_tree
        self.decoded_output=""
        for i in file_input_raw:
            if not isinstance(navigation_node,Node):
                self.decoded_output+=navigation_node[0]
                navigation_node=self.encoding_tree

            if i=='0':
                navigation_node=navigation_node.left
            elif i=='1':
                navigation_node=navigation_node.right
```

[295]:
```python
decoded_file=decoder(encoded_file.encoding_tree,"Test_text_file.
 ↪zip","Test_text_file_unzipped.txt")
decoded_file.decoded_output
```

[295]:
```
'in this paper, a novel decorrelation-based concurrent digital predistortion
(dpd) solution is proposed for dual-band transmitters (tx) employing a single
wideband power amplifier (pa), and utilizing just a single feedback receiver
```

path. the proposed decorrelation-based parameter learning solution is both flexible and simple, and operates in a closed-loop manner, opposed to the widely applied indirect learning architecture. the proposed decorrelation-based learning and dpd processing can also be effectively applied to more ordinary single-band transmissions, as well as generalized to more than two transmit bands. through a comprehensive analysis covering both the dpd parameter learning and the main path processing, it is shown that the complexity of the proposed concurrent dpd is substantially lower compared with the other state-of-the-art concurrent dpd methods. extensive set of quantitative simulation and rf measurement results are also presented, using a base-station pa as well as a commercial lte-advanced mobile pa, to evaluate and validate the effectiveness of the proposed dpd solution in various real world scenarios, incorporating single-band/dual-band tx cases. the simulation and rf measurement results demonstrate excellent linearization performance of the proposed concurrent dpd, even outperforming current state-of-the-art methods, despite the significantly lower complexity'

1.0.6 REQUIREMENT 6

Calculating efficiency of Huffman Code

[296]:
```
encoded_file.encoding
encoded_file.symbols_probabilities

average_length= sum([i[1]*len(encoded_file.encoding[i[0]]) for i in␣
↪encoded_file.symbols_probabilities])
print(f"the encoding's effieciency is {Entropy/average_length}")
```

```
the encoding's effieciency is 0.9954768209347515
```

1.0.7 REQUIREMENT 7

Creating a Shannon encoder

[297]:
```
class shannon_encoder(encoder):
    def __init__(self,file_name,file_name_output):
        self.file_name=file_name
        super().calculate_probabilities()
        self.generate_shannon_tree()
        self.encoding=super().generate_encoding()
        super().generate_encoded_message()

        with open(file_name_output, "w") as file_output:
            file_output.write(self.encoded_message)

    def generate_shannon_tree(self,symbols_probabilities=None,␣
↪navigation_node=None):

        if symbols_probabilities==None:
            symbols_probabilities=self.symbols_probabilities
```

```
        if navigation_node==None:
            self.encoding_tree=Node()
            navigation_node=self.encoding_tree



        total_probability = sum(value for _, value in symbols_probabilities)
        accumulated_probabilities = 0
        midpoint = 0

        for i, (_, probability) in enumerate(symbols_probabilities):
            accumulated_probabilities += probability
            if accumulated_probabilities >= total_probability / 2:
                midpoint = i
                break

        left_split=symbols_probabilities[:midpoint]
        right_split=symbols_probabilities[midpoint:]
        if len(symbols_probabilities)==2:
            navigation_node.left=symbols_probabilities[0]
            navigation_node.right=symbols_probabilities[1]
            return
        if len(left_split)==1:
            navigation_node.left=symbols_probabilities[0]
            navigation_node.right=Node()
            self.generate_shannon_tree(right_split,navigation_node.right)
            return

        navigation_node.left=Node()
        navigation_node.right=Node()
        self.generate_shannon_tree(left_split,navigation_node.left)
        self.generate_shannon_tree(right_split,navigation_node.right)
```

[298]:
```
from pandas import DataFrame as df
encoded_shannon=shannon_encoder("Test_text_file.txt","Test_text_file_Shannon.
 ↪zip")
symbols_probabilities=encoded_shannon.symbols_probabilities

table=df({"Symbols":encoded_shannon.encoding.values(),"Encoding":
 ↪encoded_shannon.encoding.keys()})
table
```

[298]:

	Symbols	Encoding
0	1100	d
1	1111011	-

```
2        1111010       b
3         110111       c
4            010       e
5          10111       s
6         111100       f
7       11111101       y
8        1111101       w
9        1110111       g
10      11111100       ,
11    1111111100       .
12    1111111101       )
13    1111111110       (
14         10110       r
15          1010       i
16           100       o
17         01111       n
18            00        
19          0110       a
20         01110       t
21        110110       p
22       1110110       u
23       1111100       v
24      11111110       x
25   11111111110       z
26  111111111110       /
27 1111111111110       k
28 11111111111110      q
29 11111111111111      j
30         11010       l
31        111010       m
32         11100       h
```

1.0.8 Requirement 8

Using the Decoder (same for both shannon and huffman) and Comparing the efficiency
The efficiency for both is identical, to verify if there is an error, I used the encoding tree from the previous huffman encoding for comparison to show that both encodings are in fact seperate

[299]:
```
decoded_file=decoder(encoded_shannon.encoding_tree,"Test_text_file_Shannon.
 ↪zip","Test_text_file_unzipped_Shannon.txt")
decoded_file_wrong=decoder(encoded_file.encoding_tree,"Test_text_file_Shannon.
 ↪zip","Test_text_file_unzipped_Shannon.txt")
print("Decoded file using shannon encoding tree")
print(decoded_file.decoded_output)
print("Decoded file using the previous huffman tree")
print(decoded_file_wrong.decoded_output)
```

```
Decoded file using shannon encoding tree
in this paper, a novel decorrelation-based concurrent digital predistortion
(dpd) solution is proposed for dual-band transmitters (tx) employing a single
wideband power amplifier (pa), and utilizing just a single feedback receiver
path. the proposed decorrelation-based parameter learning solution is both
flexible and simple, and operates in a closed-loop manner, opposed to the widely
applied indirect learning architecture. the proposed decorrelation-based
learning and dpd processing can also be effectively applied to more ordinary
single-band transmissions, as well as generalized to more than two transmit
bands. through a comprehensive analysis covering both the dpd parameter learning
and the main path processing, it is shown that the complexity of the proposed
concurrent dpd is substantially lower compared with the other state-of-the-art
concurrent dpd methods. extensive set of quantitative simulation and rf
measurement results are also presented, using a base-station pa as well as a
commercial lte-advanced mobile pa, to evaluate and validate the effectiveness of
the proposed dpd solution in various real world scenarios, incorporating single-
band/dual-band tx cases. the simulation and rf measurement results demonstrate
excellent linearization performance of the proposed concurrent dpd, even
outperforming current state-of-the-art methods, despite the significantly lower
complexity
Decoded file using the previous huffman tree
 epiiewn n  nghdrcpmeroaglg nrnntfimhstigciohiv  rslprw uie  cr nryxnriyephvrtnh
ein iriyep ,rtrn  eigcanrentn  i mnnmduaamhyiea r ahpjimo trt shrnhicbuilmncv o
uripe  el gcigt wa egeht n h hdripetntg (l ehiehhltiida.nhitecas nurthhaggu
iawcrriiehoetasrtrn  eigcb p  rgnntfimhstigcrr n teea re ee ritehiein iriyep ,i
siidlrnil i rndahd uut  eipcem-tngrie,fleotl eigi une ouri u  m-t   eigdudxecv o
iue      f ofhewerxe ee ritehicgtmfp  ttt r(ac asrtrn  eigcb p  rgnntfimhstigcsn
ritehicemce  ortrn t.lnhie tnprt.cted plerx iag mot     f oetdunrss  nsltrhs
uilmni mnnmduaamhy z cjac,itg  dtietteu n  wha oetdunrsetariokoetrritm spi
enm(mdxgnt tmdarligtr,eell ledalt ivl ie pmeg ehieuoxdxece  oratrrusp re ee
ritehicemdxec e slraaxcr  e t.lnhihd eayp msm piiceaetasrligt eil etmnepc asrtrn
eigciohiv  rslprrtoyp mtu taalun  r mn sm ge putn rgcvntac assiibreiiena xinvxei
riciohiv  rslprrtoisntannihabheanll lebteaslchmvri tspau lebuuvtentfioahd  petee
iv nisnxerwlt eticgse  .cr n,nxgipet i ehiccte i.xpau catnor am r  dticcintis
rturtcsp vtnlenmuaetsl gncrrhdisble  irriedahdme  wceaoii-einpgx iasl i anpc
asrtrn  eigce  o.r tntfinsliar  fv a ne  cvgtrblui  r s haeshinrt errifh a
uilmni mnnmihtntn  i mnnmdjcir t(mdxebuuvtentfioahd  petee iv nisnxerwlt etieo
tsitttrried hrutrnexe fln r ihnntfin ngls  tenmueepc asrtrn  eigciohiv
rslprrtnmd leepntnt ngls  tfh atmtr nexeiiena xinvxei   ric eetannihdawv eaoii-.
ttl p rvi t iur el ge put  eil etmh
```

[300]:
```python
average_length= sum([i[1]*len(encoded_shannon.encoding[i[0]]) for i in encoded_shannon.symbols_probabilities])
print(f"the encoding's effieciency is {Entropy/average_length}")
```

```
the encoding's effieciency is 0.9530924625884625
```

2 INFORMATION THEORY PROJECT PART 2

2.0.1 Requirement 1, 2 (encoder,channel and decoder)

[301]:
```
def file_check(file_name):

    file_check=file_name[0] not in ["0","1",1,0]

    if file_check:
        file_object = open(file_name)
        transmited_message=file_object.read();
        transmited_message=np.array(list(transmited_message),dtype=int)
        file_object.close()
        return transmited_message
    else:
        return file_name

def file_write_array_bits(file_name,message):
    if (file_name):
        file_object = open(file_name,'w')
        file_object.write(arr2str(message))
        file_object.close()

class error_encoder_decoder:
    def __init__(self,message,output_file=None):

        self.G_matrix= np.array([
            [1,1,0,1],
            [1,0,1,1],
            [1,0,0,0],
            [0,1,1,1],
            [0,1,0,0],
            [0,0,1,0],
            [0,0,0,1],
        ])

        self.H_matrix= np.array([
            [1,0,1,0,1,0,1],
            [0,1,1,0,0,1,1],
            [0,0,0,1,1,1,1],
        ])

        self.R_matrix= np.array([
            [0,0,1,0,0,0,0],
            [0,0,0,0,1,0,0],
            [0,0,0,0,0,1,0],
            [0,0,0,0,0,0,1],
        ])
```

```
        self.lookup_table= {
            (0, 0, 0): -1,
            (0, 0, 1):  3 ,
            (0, 1, 0):  1 ,
            (0, 1, 1):  5 ,
            (1, 0, 0):  0 ,
            (1, 0, 1):  4 ,
            (1, 1, 0):  2 ,
            (1, 1, 1):  6
        }


        message=file_check(message)

        message_binary=np.array(list(message),dtype=int)
        self.message_length=len(message_binary)
        self.buffer_length=4-len(message_binary)%4

        buffer=np.zeros(self.buffer_length)


        message_binary=np.concatenate((message_binary,buffer))
        self.add_parity(message_binary)

        file_write_array_bits(output_file,self.encoded_message_array)




    def add_parity(self,message_binary):

        encoded_message_array=np.zeros(int(len(message_binary)*(7/4)))
        for j,i in␣
↪zip(range(7,len(encoded_message_array)+7,7),range(4,len(message_binary)+4,4)):
↪
            encoded_message_array[j-7:j]=np.dot(self.
↪G_matrix,message_binary[i-4:i])%2

        self.encoded_message_array=encoded_message_array

    def correct_errors(self,encoded_message_array,output_name=None):

        encoded_message_array=file_check(encoded_message_array)

        total_message_length=self.message_length+self.buffer_length
```

```python
        decoded_message_array=np.zeros(total_message_length)

        for j,i in zip(range(7,len(encoded_message_array)+7,7),range(4,total_message_length+4,4)):

            word=encoded_message_array[j-7:j]
            syndrome=np.dot(self.H_matrix,word)%2
            error_bit=self.lookup_table[tuple(syndrome.astype(int))]
            if(error_bit!=-1):
                word[error_bit]^=1

            decoded_message_array[i-4:i]=np.dot(self.R_matrix,word)%2

        self.decoded_message_array=decoded_message_array
        self.decoded_message=''.join(map(str, self.decoded_message_array[:self.message_length].astype(int)))

        file_write_array_bits(output_name,self.decoded_message_array)



def arr2str(arr):
    return ''.join(map(str, arr.astype(int)))


def channel(message, SNR_dB ):

    file_check=(message[0]) not in [0,1]
    if file_check:
        file_object = open(message)
        transmited_message=file_object.read();
        transmited_message=np.array(list(transmited_message),dtype=int)
        file_object.close()
    else:
        transmited_message=message


    bit_flip_probability = 1 / (10 ** (SNR_dB / 10))
    random_values = np.random.rand(len(transmited_message))
    indices = np.where((random_values < bit_flip_probability) == True)[0]
    noisy_message=np.bitwise_xor(transmited_message.astype(int) ,(random_values < bit_flip_probability))


    if file_check:
        file_object = open(message,'w')
```

```
        file_object.write(arr2str(noisy_message))
        file_object.close()

    return noisy_message
```

2.0.2 Requirement 4 (SNR and BER plot)

testing one pass through channel

[302]:
```
def calculate_ber(string1, string2):
    if len(string1) != len(string2):
        raise ValueError("Strings must have the same length.")
    return np.sum(np.array(list(string1), dtype=int) != np.array(list(string2),␣
 ↪dtype=int)) / len(string1)
```

[303]:
```
error_encoded_message=error_encoder_decoder(encoded_shannon.encoded_message)
error_encoded_message.encoded_message_array
```

[303]:
```
array([1., 0., 1., …, 0., 0., 0.], shape=(10976,))
```

[304]:
```
sent_message_parity=channel(error_encoded_message.encoded_message_array, 20)
received_message_no_parity=channel( np.array(list(encoded_shannon.
 ↪encoded_message),dtype=int),20)

error_encoded_message.correct_errors(sent_message_parity)
received_message_parity=error_encoded_message.decoded_message
```

[305]:
```
arr2str(received_message_no_parity)
```

[305]:
```
'1010011110001110111001010101110011011001101101100101011011111100000110000111110
0111110011011010001100010110111100101101011001011010011001110101010001111111011
1111010011010111010110000110111100011111101111110110101101011001001110011100011 0
0101011101111010011110110110100011011010110010110010101011101110100101100111010 1
0100011110011111111101100110110110011111111010010111100110101110110011101010100 0
1111001010101110011011010110100110110100101110101100001111001001011000110011101 1
0011011010111101111110100110011101100000111010110011001111101111110101010011100 1
1100101011010111001111111110011101111111101111111101000101110101101101101010011 11
1101001001111111011100011000101111010011111110111110100100011111011010110001111 1
1010011001111110000110110100111101010100100001101110101101101101010101111001010
0101011000111111111011011001101111111110111111110000011001111110000111011001110101
0110101010111111111010100111111011100111111111111111110110101100111000111001 10
1111010011111110111110100100011110001001011001111010011011011110111111111100010 1
1101011011101010101111100010101110011011001100111011100111111110000011101110001 0
0011011010110100110110100101110101100001100010110111100101101011001011010011001 1
1010101000111111101111110100110101110101100001101100110101100110111010010011100
1010110001101001001101011001111101001111111011100101110001101011101100111010101 0
0011110010101011100111111010001110111000011110011010010111111101010111101011010 0
1000011001111110000101111010111010110110010100101111110010011001111110000100111 1
```

100101011001100111001010111101010011110001100011011111010100101110101100111101111
1010100100110110001110100110011110111101010110111111000010011011011011010010111010
1011000000111010000011101110001000111110110101100010110101111110100011011011011011
1011010101001011000010100111111001010101100101101110111000111100100110101100111111
1010011111110111000110101101101111110010100111001011011101110111011010110010111111
1111000000111011100010000101101011010011011010010111010110000110001011011110010111
0101100101101001100111010101000111111101111110100110101110101100001101001001101
0110011111010011111110111000110011111100001100110110110000110110101101000101110
0101111011110100110111101110011011101100111100011011010101111000011110100100001010
1111001111000101101110111010101111100010110101111110100011011011011011011010101010
0101100100111010000111011100101100100010010110110010100111101101011011111101001010
1111010011111110111110100101111011111101001100111111000001110101100110011111011111
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1010111101111110100110011111100000111011111110001101110110101110101011111111111110

```
00001110111000100000111101011101011101101101001100111010101000111100011001111110
```

[306]:
```python
print(calculate_ber(received_message_no_parity,encoded_shannon.encoded_message))
print(calculate_ber(encoded_shannon.encoded_message,encoded_shannon.
 ↪encoded_message))
print(calculate_ber(received_message_parity,encoded_shannon.encoded_message))
```

```
0.008132674214638813
0.0
0.00143517780258332
```

creating plot to create our plot accurately, we should run a set number of trials and average them

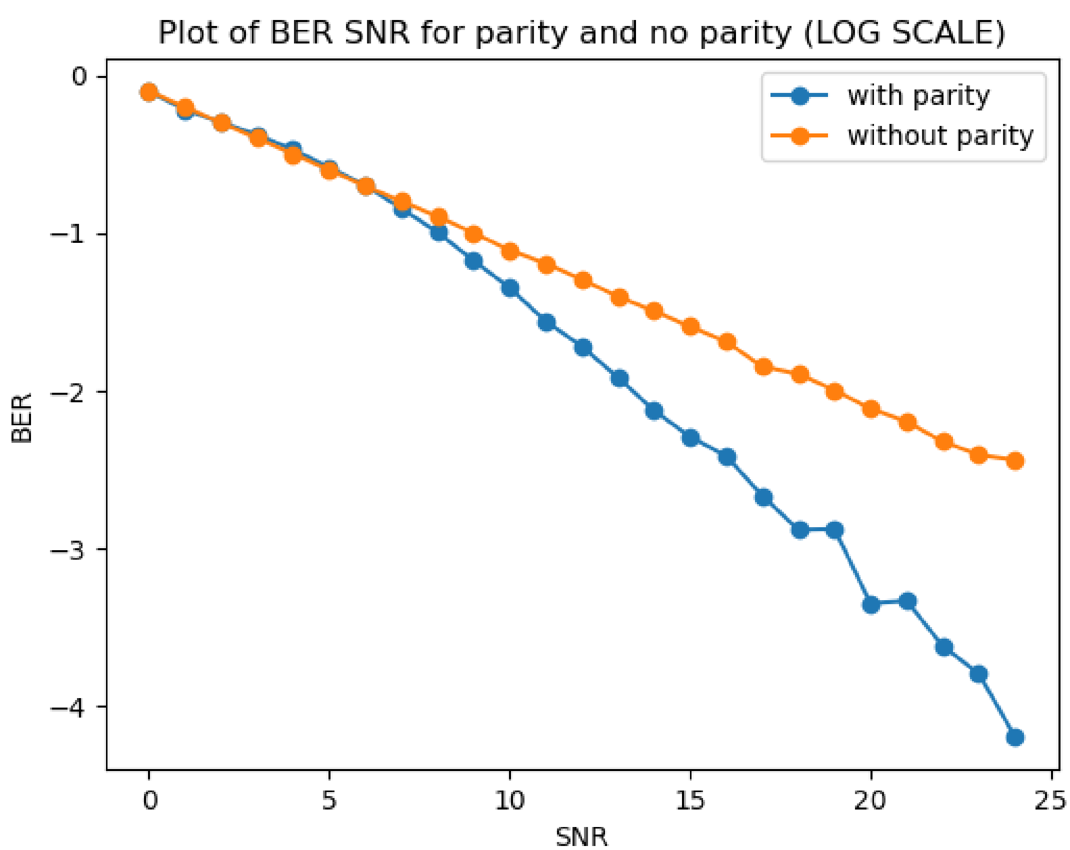
[307]:
```python
def create_data(number_of_trials, lower_snr_range,upper_snr_range):
    results_parity=np.zeros((number_of_trials,upper_snr_range-lower_snr_range))
    results_no_parity=np.
 ↪zeros((number_of_trials,upper_snr_range-lower_snr_range))

    for i in (range(lower_snr_range,upper_snr_range)):
        for j in range(0,number_of_trials):
            error_encoded_message=error_encoder_decoder(encoded_shannon.
 ↪encoded_message)
            sent_message_parity=channel(error_encoded_message.
 ↪encoded_message_array, i+1)
            received_message_no_parity=channel( np.array(list(encoded_shannon.
 ↪encoded_message)
                                                        ,dtype=int),i+1)
            error_encoded_message.correct_errors(sent_message_parity)
            received_message_parity=error_encoded_message.decoded_message

            results_no_parity[j,i-lower_snr_range]=calculate_ber(
                received_message_no_parity,encoded_shannon.encoded_message)

            results_parity[j,i-lower_snr_range]=calculate_ber(
```

```
                received_message_parity,encoded_shannon.encoded_message)

    return results_no_parity,results_parity
```

[308]:
```
results_no_parity,results_parity =create_data(10,0,25)
```

[309]:
```
results_parity_averaged= np.log10(np.mean(results_parity, axis=0))
results_no_parity_averaged= np.log10(np.mean(results_no_parity, axis=0))
```

[310]:
```
import matplotlib.pyplot as plt

plt.plot(results_parity_averaged, marker='o',label="with parity")
plt.plot(results_no_parity_averaged, marker='o',label="without parity")
plt.xlabel('SNR')
plt.ylabel('BER')
plt.title('Plot of BER SNR for parity and no parity (LOG SCALE)')
plt.legend()
plt.show()
```



2.0.3 REQUIREMENT 5 INTEGRATION

for this I will use huffman code

20 SNR

[311]:
```python
encoded_file=huffman_encoder("Test_text_file.txt","Test_text_file_20SNR.zip")
error_encoded_file=error_encoder_decoder("Test_text_file_20SNR.
 ↪zip","Test_text_file_20SNR_error_encoded.zip")

channel("Test_text_file_20SNR.zip",20)

channel("Test_text_file_20SNR_error_encoded.zip",20)

error_encoded_file.correct_errors("Test_text_file_20SNR_error_encoded.
 ↪zip","Test_text_file_20SNR_error_decoded.zip")

decoded_file=decoder(encoded_file.encoding_tree,"Test_text_file_20SNR.
 ↪zip","Test_text_file_20SNR.txt")
print(decoded_file.decoded_output)

decoded_file=decoder(encoded_file.
 ↪encoding_tree,"Test_text_file_20SNR_error_decoded.
 ↪zip","Test_text_file_20SNR_error_encoding.txt")
decoded_file.decoded_output
```

```
in this papei, a novctsdopieolrr paooei-ed concurrent digital reooete ortion
(dpd) rolution is pueaosed for dual-band transmitters (tz l employing a single
widebano power amplifidttiheo l, and utilizing  ih ee  a single
feedbacrmtreceirag path. the proposed decorrelation-based parameteumearning
solution ia both flexible and simple, and operates in a closed-loop
maoneritreaposedeto the widely applied indirect learning architectmre. the pro
edosesdopenomation-based learning a-esead processing can also be effectively
applied toemore orditary single-wned transmissions, as w ll as generalized to
more thann won ransmrt bands. through a comlrehensive analysis covering both the
spd parameter icoteing and the t olrlrrhtprocessing, it is shown that
theoeaitalexit, of the proposed concurrent dpd is substantially lower cdmpared
with ttatother state-of-the-arteconcurrentocobmenhodsctslvnnsive set ofnt
ttrsumptive simrntn ion ancgf measurement resulngpre also presetted, using a
base-station pa as well as a commerciahit edeoc  neced mobile pattireslmi trrn
tnd validaftthe d bdol mars - af the proposed dpdonctt r pstin various real world
sciearios, incorporating siogle-bandkdual-band tx cases. the sehig n ion and rf
measurement results demonstrate excellent linearizateostperformaoce of the
proposed concurrent dpd, eaarraiglbnsorming btenoav e ate-of-the-art methods,
despite the dignifibnetly lower complexity
```

[311]: 'in this paper, a novel decorrelation-based concurrent digital predistortion (dpd) solution is proposed for dual-band transmitters (tx) employing a single wideband power amplifieir haa), and utilizing just a single feedback receiver path. the proposed decorrelation-based parameter learning solution is both flexible and simple, and operates in a closed-loop manner, opposed to the widely applied indirect learning architecture. the proposed decorrelation-based learning and dpd processing can also be effectively applied to more ordinary single-band transmissions, as well as generalized to more than two transmit bands. through a comprehensive analysis covering both the dpd parameter learning and the main path processing, it is shown that the complexity of the proposed concurrent dpd is substantially lower compared with the other state-of-the-art concurrent dpd methods. extensive set of quantitative simulation and rf measurement results are also presented, using a base-station pa as well as a commercial lte-advanced mobile pa, to evaluate and validate the effectiveness of the proposed dpd solution in various real world scenarios, incorporating single-band/dual-band tx cases. the simulation and rf measurement results demonstrate excellent linearization performance of the proposed concurrent dpd, even outperforming current state-of-the-art methods, despite the significantly lower complexity.'

10 SNR

[312]:
```
encoded_file=huffman_encoder("Test_text_file.txt","Test_text_file_10SNR.zip")
error_encoded_file=error_encoder_decoder("Test_text_file_10SNR.
 ↪zip","Test_text_file_10SNR_error_encoded.zip")

channel("Test_text_file_10SNR.zip",10)

channel("Test_text_file_10SNR_error_encoded.zip",10)

error_encoded_file.correct_errors("Test_text_file_10SNR_error_encoded.
 ↪zip","Test_text_file_10SNR_error_decoded.zip")

decoded_file=decoder(encoded_file.encoding_tree,"Test_text_file_10SNR.
 ↪zip","Test_text_file_10SNR.txt")
print(decoded_file.decoded_output)

decoded_file=decoder(encoded_file.
 ↪encoding_tree,"Test_text_file_10SNR_error_decoded.
 ↪zip","Test_text_file_10SNR_error_encoding.txt")
decoded_file.decoded_output
```

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tpiicrrdefii ale, and orb sose)ta ehd-soslaavhpnneritpieaofo,orhlr gud
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[312]:
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the wsoely applied indirect micsna r srih lnctug reiilrle cniodor-raaaitn ion-
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than two transmitlsdnds.craueterh a bcoreohnnsive
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sedlielmpety.'
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15 SNR

[313]:
```python
encoded_file=huffman_encoder("Test_text_file.txt","Test_text_file_15SNR.zip")
error_encoded_file=error_encoder_decoder("Test_text_file_15SNR.
 ↪zip","Test_text_file_15SNR_error_encoded.zip")

channel("Test_text_file_15SNR.zip",15)

channel("Test_text_file_15SNR_error_encoded.zip",15)

error_encoded_file.correct_errors("Test_text_file_15SNR_error_encoded.
 ↪zip","Test_text_file_15SNR_error_decoded.zip")
```

```python
decoded_file=decoder(encoded_file.encoding_tree,"Test_text_file_15SNR.
 ↪zip","Test_text_file_15SNR.txt")
print(decoded_file.decoded_output)

decoded_file=decoder(encoded_file.
 ↪encoding_tree,"Test_text_file_15SNR_error_decoded.
 ↪zip","Test_text_file_15SNR_error_encoding.txt")
decoded_file.decoded_output
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[313]:
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widebapbpower amplifier (pa), and utilizing just a single feedback receiver
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applied indirect learning architectvswtiilrle cndosesdop-aitneion-based hics p r
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transmisdions, as well as generamhnoo,a(seotthan two transmit bands. through
tecomprehensive analysis coveigwfge h theo,d.re nleter learning and the main
path processing, it is shown that the complexity of the proposed concurrent dpd
is substantially lower compared with the other state-of-the-art concurrent dpd
methods. extensive set of quantitative simulation and rf measurement ebeti  s
are also presented, using a base-station pa as well as a commercial lte-advanced
mobile pa, to evaluate and validate the effectiveness of the proposed dpd
solution in various real woinbtdrricepe-l rsidtaee g p r single-band/dual-band t
ifioof. the e h ti n ion and rf measurement results demonstrate excellent
linearization performance of the propssed concurrent dpd,ri oatoutperforming
current state-of-the-art methods, despite the significantly lower complexi  f p'
```

[ ]:

```

```