## Submitted by: Ashish Jain

HomeWork 2A

**Question 1.**

Part 1.1)

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **POS** | E | T | A | I | N | O | S | H | R | D |
| 1 | -7.6443 | 18.468 | -6.3285 | 10.4224 | -4.9671 | -1.934 | -0.9451 | -5671 | 5.395 | -6.8098 |
| 2 | -4.0744 | 5.7448 | 1.1763 | -1.7931 | -1.2122 | -1.7848 | -8.2998 | 3.0951 | 6.8065 | 0.34161 |
| 3 | -10.208 | 0.8973 | 17.1910 | -12.017 | 5.5793 | -0.594 | -21.426 | 9.1489 | 9.4824 | 1.9471 |
| 4 | 6.4648 | 24.531 | -13.342 | 5.8712 | -10.954 | -11.496 | -5.4946 | -7.1956 | 8.0456 | 3.5714 |

Part 1.2)

|  |  |
| --- | --- |
| **Words** | **-Ew** |
| THAT | 63.9793 |
| HIRE | 89.6109 |
| RISES | 96.9406 |

Part 1.3)

|  |  |
| --- | --- |
| **Words** | **log Z (log partition function)** |
| THAT | 67.6018 |
| HIRE | 89.6144 |
| RISES | 103.5275 |

Part 1.4)

|  |  |  |
| --- | --- | --- |
| **Test Image** | **Likely Labeling** | **Probability** |
| THAT | TRAT | 0.7958 |
| HIRE | HIRE | 0.9965 |
| RISES | RISER | 0.937 |

Part 1.5) First test word: TEST

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Position 1** | **Position 2** | **Position 3** | **Position 4** |
| E | 7.2226e-12 | 1.2658e-05 | 1.1321e-12 | 8.8682e-09 |
| T | 0.9995 | 0.1724 | 2.2945e-08 | 0.9999 |
| A | 2.6261e-11 | 0.0027 | 0.9994 | 2.1356e-17 |
| I | 0.0004 | 0.0001 | 1.6118e-13 | 7.4054e-09 |
| N | 7.1555e-11 | 0.0002 | 3.6975e-06 | 3.29e-16 |
| O | 2.1138e-09 | 0.0001 | 1.761e-08 | 1.441e-16 |
| S | 3.2959e-09 | 1.0646e-07 | 5.1721e-18 | 5.371e-14 |
| H | 4.3492e-11 | 0.0267 | 0.0002 | 1.3178e-14 |
| R | 2.628e-06 | 0.7965 | 0.0002 | 6.3939e-08 |
| D | 1.0693e-11 | 0.0009 | 9.4637e-08 | 6.3736e-10 |

**Question 2)**

**Part 2.1)**

**Clique 1:**

|  |  |  |  |
| --- | --- | --- | --- |
|  | T | A | H |
| T | 17.814 | 18.749 | 18.8338 |
| A | -6.0478 | -6.5592 | -6.2812 |
| H | -5.2916 | -5.6097 | -5.7932 |

**Clique 2:**

|  |  |  |  |
| --- | --- | --- | --- |
|  | T | A | H |
| T | 5.091 | 6.0255 | 6.1103 |
| A | 1.457 | 0.9456 | 1.2237 |
| H | 3.4606 | 3.1425 | 2.959 |

**Clique 3:**

|  |  |  |  |
| --- | --- | --- | --- |
|  | T | A | H |
| T | 24.7748 | -12.1648 | -5.9327 |
| A | 42.0029 | 3.6173 | 10.0427 |
| H | 34.0456 | -4.1466 | 1.8171 |

**Part 2.2)**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Messages** | **E** | **T** | **A** | **I** | **N** | **O** | **S** | **H** | **R** | **D** |
| (Y2) | 18.589 | 17.815 | 18.749 | 18.522 | 18.180 | 18.677 | 18.091 | 18.834 | 18.363 | 18.216 |
| (Y2) | 25.651 | 25.236 | 25.598 | 25.577 | 25.271 | 25.601 | 25.071 | 25.388 | 25.414 | 25.202 |
|  | 37.735 | 48.029 | 42.949 | 40.43 | 40.907 | 40.051 | 33.455 | 45.146 | 49.011 | 42.411 |
|  | 14.443 | 24.774 | 42.002 | 12.567 | 29.822 | 24.145 | 2.727 | 34.045 | 33.908 | 26.226 |

**Part 2.3)**

|  |  |  |
| --- | --- | --- |
|  | **T** | **A** |
| **T** | 65.843 | 61.698 |
| **A** | 41.981 | 36.39 |

|  |  |  |
| --- | --- | --- |
|  | **T** | **A** |
| **T** | 47.681 | 65.843 |
| **A** | 44.981 | 61.697 |

|  |  |  |
| --- | --- | --- |
|  | **T** | **A** |
| **T** | 50.011 | 13.071 |
| **A** | 67.601 | 29.215 |

**Part 2.4)**

**Pairwise Marginals for labels “t,a,h”**

**Clique 1:**

|  |  |  |  |
| --- | --- | --- | --- |
|  | T | A | H |
| T | 0.1723 | 0.0027 | 0.0267 |
| A | 7.4658e-12 | 2.7859e-14 | 3.3086e-13 |
| H | 1.5904e-11 | 7.20009e-14 | 5.3896e-13 |

**Clique 2:**

|  |  |  |  |
| --- | --- | --- | --- |
|  | T | A | H |
| T | 2.2314e-09 | 0.1723 | 6.56861e-05 |
| A | 1.49969e-10 | 0.00272 | 1.2615e-06 |
| H | 1.2104e-09 | 0.0267 | 7.7862 |

**Clique 3:**

|  |  |  |  |
| --- | --- | --- | --- |
|  | T | A | H |
| T | 2.2945e-08 | 2.0795e-24 | 1.0580e-21 |
| A | 0.9994 | 2.1336e-17 | 1.3170e-14 |
| H | 0.00028 | 7.3431e-21 | 2.857e-18 |

**Marginal distribution:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Position 1** | **Position 2** | **Position 3** | **Position 4** |
| E | 7.222e-12 | 1.2658 | 1.1321e-12 | 8.8682e-09 |
| T | 0.9995 | 0.1724 | 2.2945e-08 | 0.9999 |
| A | 2.6261e-11 | 0.0027 | 0.9994 | 2.1356e-17 |
| I | 0.00047 | 0.00017 | 1.6118e-13 | 7.4054e-09 |
| N | 7.15554e-11 | 0.0002 | 3.6975e-06 | 3.29e-16 |
| O | 2.1138e-09 | 0.00014 | 1.761e-08 | 1.441e-16 |
| S | 3.2959e-09 | 1.0646e-07 | 5.1721e-18 | 5.371e-14 |
| H | 4.3492e-11 | 0.02673 | 0.00028 | 1.3178e-14 |
| R | 2.628e-06 | 0.7965 | 0.00025 | 6.3939e-08 |
| D | 1.0693e-11 | 0.000936 | 9.4637e-08 | 6.3736e-10 |

**Part 2.5)**

Predictions for first five test sequences:

|  |  |
| --- | --- |
| **Test Word** | **Predicted Word** |
| THAT | TRAT |
| HIRE | HIRE |
| RISES | RISER |
| EDISON | EDISON |
| SHORE | SHORE |

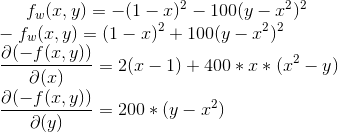
**Accuracy:** Total number of correct characters/total number of characters **= 89.916**

**Question 4)**

**4.1** Since we need to maximize f(x,y), we multiply it by negative sign and take its derivative. Then we can use numerical optimizer from python library to minimize

-f(x,y).

Minimizing –f(x,y) will give us maximum for f(x,y). Therefore, we find derivatives for –f(x,y) as shown below.



**4.2** I used bfgs\_min numerical optimizer from python scipy package. This optimizer minimizes the input function and returns co-ordinates at which minima is achieved.

**Code:**

from numpy import \*

from scipy.optimize import fmin\_bfgs

def objective\_function(x):

val = (1-x[0])\*\*2 + 100\*(x[1]-x[0]\*\*2)\*\*2

return val

def gradient\_function(x):

derivative = zeros\_like(x)

derivative[0] = 2\*(x[0]-1)+400\*(x[0])\*(x[0]\*\*2 - x[1])

derivative[1] = 200\*(x[1]-x[0]\*\*2)

return derivative

def main():

x0 = [1.3, 0.7]

xopt = fmin\_bfgs(objective\_function, x0, fprime=gradient\_function, disp=True, retall=True)

print xopt

if \_\_name\_\_ == "\_\_main\_\_":

main()

**Output:**

Current function value: 0.000000

Iterations: 40

Function evaluations: 57

Gradient evaluations: 57

**Location of maximum value =** (x, y) = (1.0, 1.0)

**Value of objective function at the maximum =** 0.0