For the second-order source extension, we examine the symbols as pairs rather than individually, observing the dependencies and relationships between the symbols.
As in the previous question, we need to identify all the pairs that exist within the image. Therefore, we will look at the neighbor of each pixel to see which pairs are present.

Identification of discrete symbols:
We will look for horizontal and vertical pairs (all neighboring pixels).
Two variables will be needed to store all the pairs, as well as code to generate them.

The variables:

```
orizodia_zeugaria = containers.Map('KeyType', 'char', 'ValueType',
'double');

katheta_zeugaria = containers.Map('KeyType', 'char', 'ValueType',
'double');
```

The method of creating pairs :

```
for i = 1:row
    for j = 1:(col - 1)
orizodio_zeugari = [image(i, j), image(i, j + 1)];
```

Where in the loop, it takes the pixel where the counter is located and pairs it with the next one in the row. In the same way, we create the vertical pair:

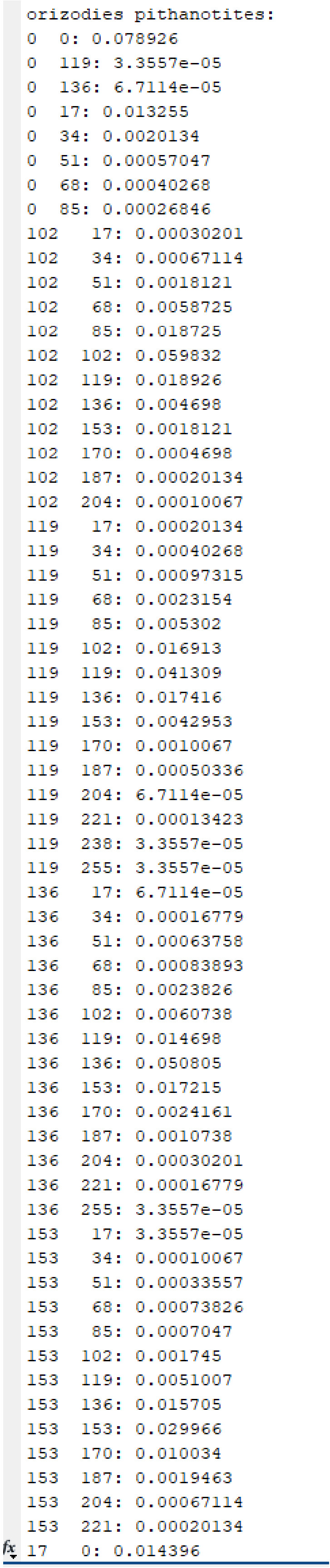
```
for i = 1:(row - 1)
    for j = 1:col
katheto_zeugari= [image(i, j), image(i + 1, j)];
```

Let’s proceed with finding the probabilities. As we did in **Question 1**, we will divide each horizontal pair by the total number of horizontal pairs, and similarly for each vertical pair.

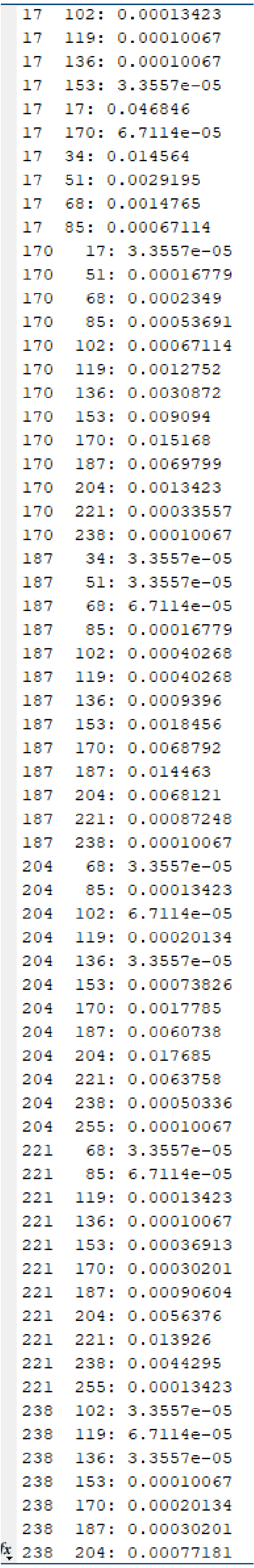
```
orizodies_pithanotites = zeros(1, length(horizontal_keys));
for i = 1:length(horizontal_keys)
    arithos_emfaniseon = orizodia_zeugaria(horizontal_keys{i});
    pithanotita = arithos_emfaniseon / sinolika_orizodia_zeugaria;
    orizodies_pithanotites(i) = pithanotita;
```

Αρχικά δημιουργούμε το array orizodies_pithanotites στο οποίο θα αποθηκεύετε η First, we create the orizodies_pithanotites array, where the probability of each pair will be stored. Then, the loop counts how many times each pair appears in the image and stores the result in the variable arithmos_emfaniseon. Finally, we calculate the probability as mentioned above and store the result in the array. We use the same method to find the vertical probabilities.

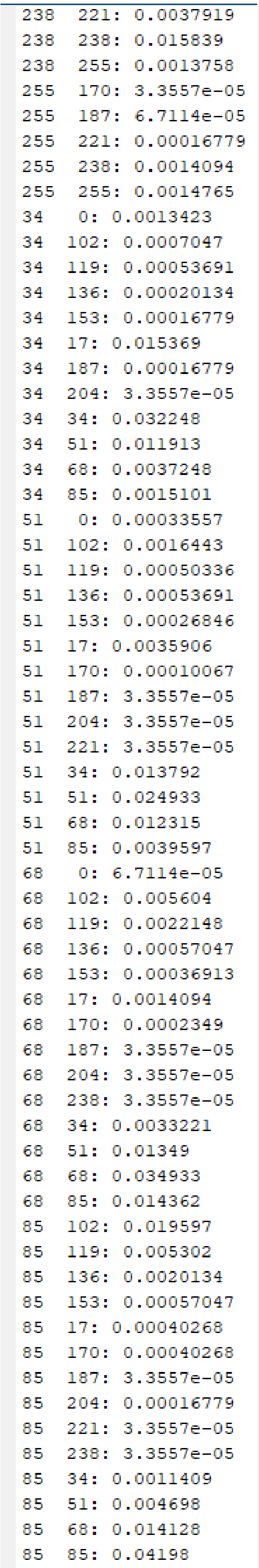
The results we obtain:



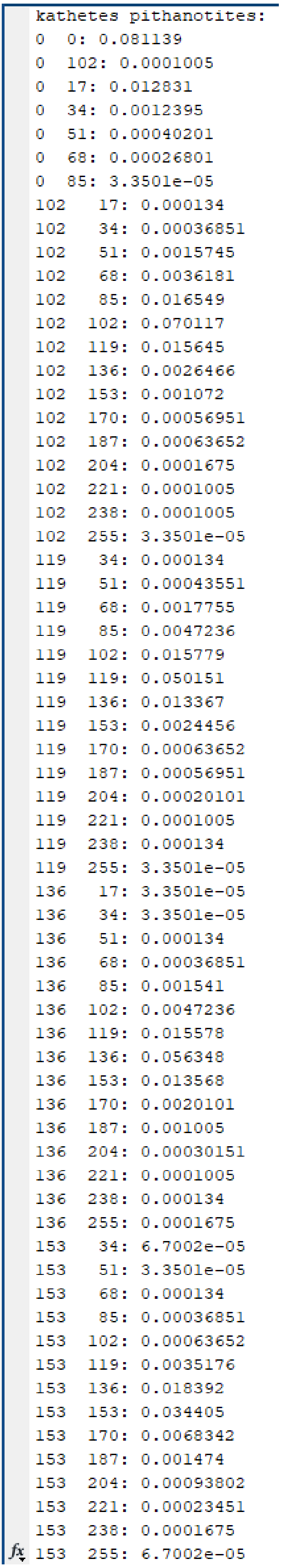
```
orizodies pithanotites:
0  0: 0.078926
0  119: 3.3557e-05
0  136: 6.7114e-05
0  17: 0.013255
0  34: 0.0020134
0  51: 0.00057047
0  68: 0.00040268
0  85: 0.00026846
102   17: 0.00030201
102   34: 0.00067114
102   51: 0.0018121
102   68: 0.0058725
102   85: 0.018725
102  102: 0.059832
102  119: 0.018926
102  136: 0.004698
102  153: 0.0018121
102  170: 0.0004698
102  187: 0.00020134
102  204: 0.00010067
119   17: 0.00020134
119   34: 0.00040268
119   51: 0.00097315
119   68: 0.0023154
119   85: 0.005302
119  102: 0.016913
119  119: 0.041309
119  136: 0.017416
119  153: 0.0042953
119  170: 0.0010067
119  187: 0.00050336
119  204: 6.7114e-05
119  221: 0.00013423
119  238: 3.3557e-05
119  255: 3.3557e-05
136   17: 6.7114e-05
136   34: 0.00016779
136   51: 0.00063758
136   68: 0.00083893
136   85: 0.0023826
136  102: 0.0060738
136  119: 0.014698
136  136: 0.050805
136  153: 0.017215
136  170: 0.0024161
136  187: 0.0010738
136  204: 0.00030201
136  221: 0.00016779
136  255: 3.3557e-05
153   17: 3.3557e-05
153   34: 0.00010067
153   51: 0.00033557
153   68: 0.00073826
153   85: 0.0007047
153  102: 0.001745
153  119: 0.0051007
153  136: 0.015705
153  153: 0.029966
153  170: 0.010034
153  187: 0.0019463
153  204: 0.00067114
153  221: 0.00020134
17    0: 0.014396
```



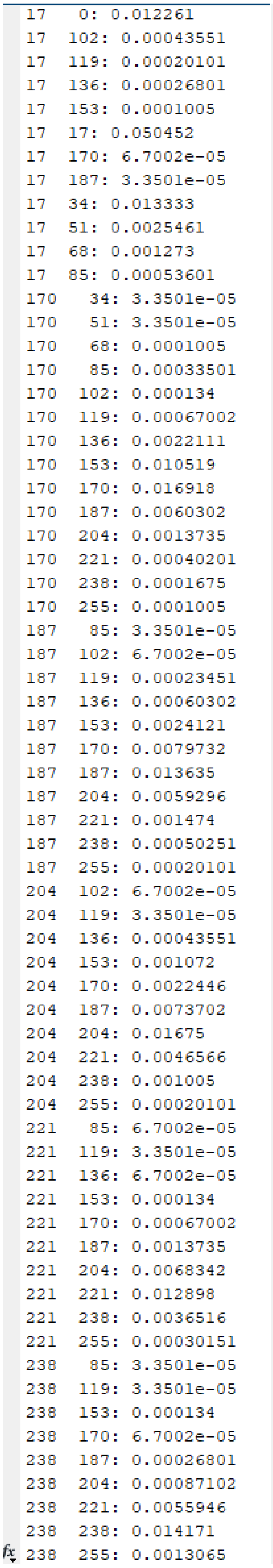
```
17  102: 0.00013423
17  119: 0.00010067
17  136: 0.00010067
17  153: 3.3557e-05
17  17: 0.046846
17  170: 6.7114e-05
17  34: 0.014564
17  51: 0.0029195
17  68: 0.0014765
17  85: 0.00067114
170   17: 3.3557e-05
170   51: 0.00016779
170   68: 0.0002349
170   85: 0.00053691
170  102: 0.00067114
170  119: 0.0012752
170  136: 0.0030872
170  153: 0.009094
170  170: 0.015168
170  187: 0.0069799
170  204: 0.0013423
170  221: 0.00033557
170  238: 0.00010067
187   34: 3.3557e-05
187   51: 3.3557e-05
187   68: 6.7114e-05
187   85: 0.00016779
187  102: 0.00040268
187  119: 0.00040268
187  136: 0.0009396
187  153: 0.0018456
187  170: 0.0068792
187  187: 0.014463
187  204: 0.0068121
187  221: 0.00087248
187  238: 0.00010067
204   68: 3.3557e-05
204   85: 0.00013423
204  102: 6.7114e-05
204  119: 0.00020134
204  136: 3.3557e-05
204  153: 0.00073826
204  170: 0.0017785
204  187: 0.0060738
204  204: 0.017685
204  221: 0.0063758
204  238: 0.00050336
204  255: 0.00010067
221   68: 3.3557e-05
221   85: 6.7114e-05
221  119: 0.00013423
221  136: 0.00010067
221  153: 0.00036913
221  170: 0.00030201
221  187: 0.00090604
221  204: 0.0056376
221  221: 0.013926
221  238: 0.0044295
221  255: 0.00013423
238  102: 3.3557e-05
238  119: 6.7114e-05
238  136: 3.3557e-05
238  153: 0.00010067
238  170: 0.00020134
238  187: 0.00030201
238  204: 0.00077181
```



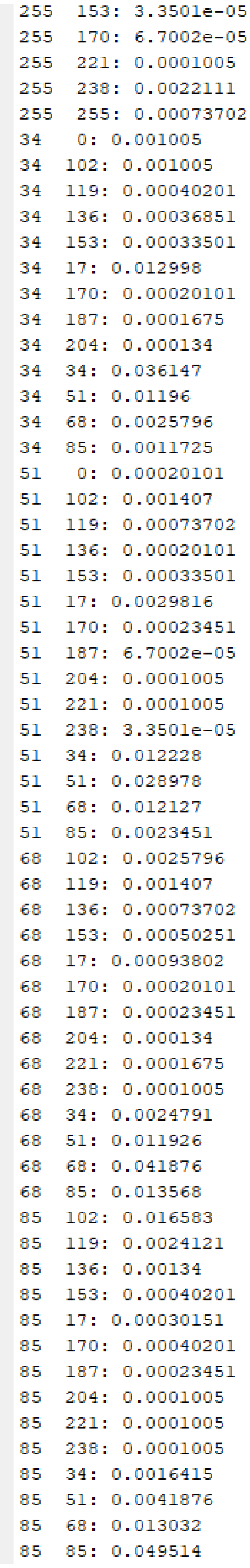
```
238  221: 0.0037919
238  238: 0.015839
238  255: 0.0013758
255  170: 3.3557e-05
255  187: 6.7114e-05
255  221: 0.00016779
255  238: 0.0014094
255  255: 0.0014765
34    0: 0.0013423
34  102: 0.0007047
34  119: 0.00053691
34  136: 0.00020134
34  153: 0.00016779
34  17: 0.015369
34  187: 0.00016779
34  204: 3.3557e-05
34  34: 0.032248
34  51: 0.011913
34  68: 0.0037248
34  85: 0.0015101
51    0: 0.00033557
51  102: 0.0016443
51  119: 0.00050336
51  136: 0.00053691
51  153: 0.00026846
51  17: 0.0035906
51  170: 0.00010067
51  187: 3.3557e-05
51  204: 3.3557e-05
51  221: 3.3557e-05
51  34: 0.013792
51  51: 0.024933
51  68: 0.012315
51  85: 0.0039597
68    0: 6.7114e-05
68  102: 0.005604
68  119: 0.0022148
68  136: 0.00057047
68  153: 0.00036913
68  17: 0.0014094
68  170: 0.0002349
68  187: 3.3557e-05
68  204: 3.3557e-05
68  238: 3.3557e-05
68  34: 0.0033221
68  51: 0.01349
68  68: 0.034933
68  85: 0.014362
85  102: 0.019597
85  119: 0.005302
85  136: 0.0020134
85  153: 0.00057047
85  17: 0.00040268
85  170: 0.00040268
85  187: 3.3557e-05
85  204: 0.00016779
85  221: 3.3557e-05
85  238: 3.3557e-05
85  34: 0.0011409
85  51: 0.004698
85  68: 0.014128
85  85: 0.04198
```



```
kathetes pithanotites:
0  0: 0.081139
0  102: 0.0001005
0  17: 0.012831
0  34: 0.0012395
0  51: 0.00040201
0  68: 0.00026801
0  85: 3.3501e-05
102   17: 0.000134
102   34: 0.00036851
102   51: 0.0015745
102   68: 0.0036181
102   85: 0.016549
102  102: 0.070117
102  119: 0.015645
102  136: 0.0026466
102  153: 0.001072
102  170: 0.00056951
102  187: 0.00063652
102  204: 0.0001675
102  221: 0.0001005
102  238: 0.0001005
102  255: 3.3501e-05
119   34: 0.000134
119   51: 0.00043551
119   68: 0.0017755
119   85: 0.0047236
119  102: 0.015779
119  119: 0.050151
119  136: 0.013367
119  153: 0.0024456
119  170: 0.00063652
119  187: 0.00056951
119  204: 0.00020101
119  221: 0.0001005
119  238: 0.000134
119  255: 3.3501e-05
136   17: 3.3501e-05
136   34: 3.3501e-05
136   51: 0.000134
136   68: 0.00036851
136   85: 0.001541
136  102: 0.0047236
136  119: 0.015578
136  136: 0.056348
136  153: 0.013568
136  170: 0.0020101
136  187: 0.001005
136  204: 0.00030151
136  221: 0.0001005
136  238: 0.000134
136  255: 0.0001675
153   34: 6.7002e-05
153   51: 3.3501e-05
153   68: 0.000134
153   85: 0.00036851
153  102: 0.00063652
153  119: 0.0035176
153  136: 0.018392
153  153: 0.034405
153  170: 0.0068342
153  187: 0.001474
153  204: 0.00093802
153  221: 0.00023451
153  238: 0.0001675
153  255: 6.7002e-05
```



```
17   0: 0.012261
17  102: 0.00043551
17  119: 0.00020101
17  136: 0.00026801
17  153: 0.0001005
17  17: 0.050452
17  170: 6.7002e-05
17  187: 3.3501e-05
17  34: 0.013333
17  51: 0.0025461
17  68: 0.001273
17  85: 0.00053601
170   34: 3.3501e-05
170   51: 3.3501e-05
170   68: 0.0001005
170   85: 0.00033501
170  102: 0.000134
170  119: 0.00067002
170  136: 0.0022111
170  153: 0.010519
170  170: 0.016918
170  187: 0.0060302
170  204: 0.0013735
170  221: 0.00040201
170  238: 0.0001675
170  255: 0.0001005
187   85: 3.3501e-05
187  102: 6.7002e-05
187  119: 0.00023451
187  136: 0.00060302
187  153: 0.0024121
187  170: 0.0079732
187  187: 0.013635
187  204: 0.0059296
187  221: 0.001474
187  238: 0.00050251
187  255: 0.00020101
204  102: 6.7002e-05
204  119: 3.3501e-05
204  136: 0.00043551
204  153: 0.001072
204  170: 0.0022446
204  187: 0.0073702
204  204: 0.01675
204  221: 0.0046566
204  238: 0.001005
204  255: 0.00020101
221   85: 6.7002e-05
221  119: 3.3501e-05
221  136: 6.7002e-05
221  153: 0.000134
221  170: 0.00067002
221  187: 0.0013735
221  204: 0.0068342
221  221: 0.012898
221  238: 0.0036516
221  255: 0.00030151
238   85: 3.3501e-05
238  119: 3.3501e-05
238  153: 0.000134
238  170: 6.7002e-05
238  187: 0.00026801
238  204: 0.00087102
238  221: 0.0055946
238  238: 0.014171
238  255: 0.0013065
```



```
255  153: 3.3501e-05
255  170: 6.7002e-05
255  221: 0.0001005
255  238: 0.0022111
255  255: 0.00073702
34   0: 0.001005
34  102: 0.001005
34  119: 0.00040201
34  136: 0.00036851
34  153: 0.00033501
34  17: 0.012998
34  170: 0.00020101
34  187: 0.0001675
34  204: 0.000134
34  34: 0.036147
34  51: 0.01196
34  68: 0.0025796
34  85: 0.0011725
51   0: 0.00020101
51  102: 0.001407
51  119: 0.00073702
51  136: 0.00020101
51  153: 0.00033501
51  17: 0.0029816
51  170: 0.00023451
51  187: 6.7002e-05
51  204: 0.0001005
51  221: 0.0001005
51  238: 3.3501e-05
51  34: 0.012228
51  51: 0.028978
51  68: 0.012127
51  85: 0.0023451
68  102: 0.0025796
68  119: 0.001407
68  136: 0.00073702
68  153: 0.00050251
68  17: 0.00093802
68  170: 0.00020101
68  187: 0.00023451
68  204: 0.000134
68  221: 0.0001675
68  238: 0.0001005
68  34: 0.0024791
68  51: 0.011926
68  68: 0.041876
68  85: 0.013568
85  102: 0.016583
85  119: 0.0024121
85  136: 0.00134
85  153: 0.00040201
85  17: 0.00030151
85  170: 0.00040201
85  187: 0.00023451
85  204: 0.0001005
85  221: 0.0001005
85  238: 0.0001005
85  34: 0.0016415
85  51: 0.0041876
85  68: 0.013032
85  85: 0.049514
```