

LBP算法实验报告

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简介

LBP (Local Binary Pattern, 局部二值模式) 是一种用来描述局部纹理特征的算子, 具有旋转不变性 (加入处理) 和亮度不变性等特征, 可以用于纹理分类、人脸识别等应用场景。

本次实验首先对LBP算法进行了实现, 对比了有无旋转不变性的图像特征, 之后绘制了LBP特征直方图, 最后使用两组图片进行了人脸识别测试, 使用了加权卡方检验, 公式如下:

$$\chi_w^2(\mathbf{S}, \mathbf{M}) = \sum_{i,j} w_j \frac{(S_{i,j} - M_{i,j})^2}{S_{i,j} + M_{i,j}},$$

旋转不变性指的是不同旋转角度下, 得到的LBP值相同。本实验中计算LBP时, 默认从左上角开始, 顺时针进行。要实现旋转不变, 只需要在从任意一个Neighbor开始计算得到的LBP值中选择最小值即可。这一过程可以直接通过将二进制数右移至最低位为1, 这样计算速度更快。在使用旋转不变后, 由于灰度值存在下降, 得到的图片纹理更加明显, 图片整体更黑。示意图如下:

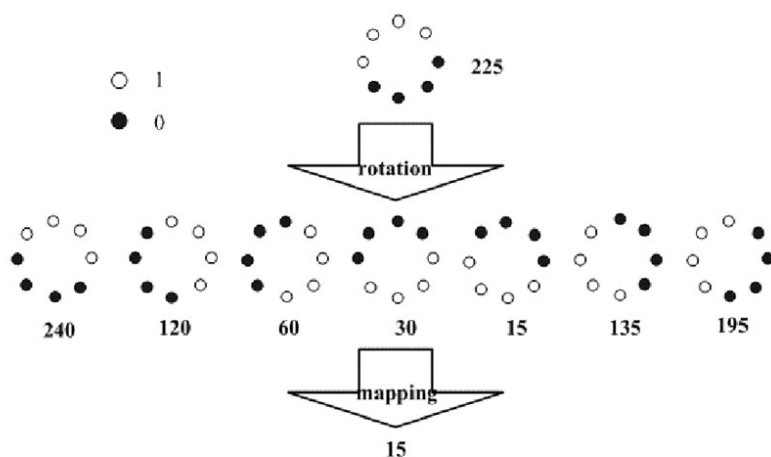


图 2.5 旋转不变的 LBP 示意

从实验结果来看，当Gallery中存在匹配的人脸图片时，LBP算法可以较好实现人脸识别。但是在表情不同、人脸位置不同的情况下，匹配效果不是很理想。考虑不理想的原因有以下几条：

1. 图片数据是自己在网上随机查找并统一处理成224x224的，数据量少，角度表情不一，并且图片中存在较多干扰，面部图像没有占据整张图片，并且诸如“瘡子”这样的特征在图像上显现不出来。
2. LBP算法本身可以进一步添加更多参数，而在本实验中重点在于理解原理，因此没有过多关注参数对结果的影响。
3. 图像分割方法给LBP带来局限。由于LBP划分Block时是横平竖直的，并且分割之后一定程度上消除了各部分的联系，这样对于一些不标准的图片就会匹配不佳。

总体来说，LBP算法计算简单，亮度不变性较强，而对人像的角度、大小、表情等要求较高。除了结合其他图像处理技术外，上述局限性可以通过对人脸数据采集过程提高标准来解决，比如我们在日常生活中使用手机进行一些高安全性人脸识别时，通常被要求面部填满给出的框架，并且要更换角度（比如点点头、左右转等），以及张开嘴巴等。在进行严格的图像采集后，人脸识别算法也更加精准安全，因此LBP算法应用也较为方便。

算法实现

```
In [4]: import torch
import cv2
import numpy as np
import time
```

```
In [5]: # Preprocess: convert color of images
# for i in range(5):
#     f = cv2.imread(f"./Trump/Trump{i}.jpg")
#     G = cv2.cvtColor(f, cv2.COLOR_BGR2GRAY)
#     cv2.imwrite(f"Trump{i}.jpg", G)
```

```
In [6]: G = cv2.imread('./Trump/Trump0.jpg', cv2.IMREAD_GRAYSCALE)
cv2.imshow('Trump0.jpg', G)
cv2.waitKey(2000) # 2000ms delay
cv2.destroyAllWindows()
```

```
In [7]: # Convert binary to decimal.
```

```
def b2d(num, rot_inv=1):
    assert len(num)==8, f"8 bits needed!"
    decimal = 0
    zeros = 0
    for i in range(8):
        if (num[7-i]==0):
            zeros+=1
        else:
            break
    for i in range(8):
        assert num[i]==0 or num[i]==1, f"Wrong bit" #ensure 0 or 1
        decimal += num[i]*2**(7-i)
    # The rotational invariance means that we use the minimum LBP value in the set that we start with
    # It is achieved by bit shift here, which is really fast.
    if (rot_inv==1 and zeros!=8):
        decimal = decimal>>zeros
    #print(decimal)
    return decimal
```

```
In [8]: # Encode the LBP feature value for each center.
def encode(src, i, j, rot_inv=1):
    binary = []
    center = src[i, j]
    # clockwise, high to low bit, 128 to 1
    b1 = src[i-1, j-1]>=center
    b2 = src[i-1, j]>=center
    b3 = src[i-1, j+1]>=center
    b4 = src[i, j+1]>=center
    b5 = src[i+1, j+1]>=center
    b6 = src[i+1, j]>=center
    b7 = src[i+1, j-1]>=center
    b8 = src[i, j-1]>=center
    binary.extend([b1, b2, b3, b4, b5, b6, b7, b8])
    dec = b2d(binary, rot_inv)
    dec = np.uint8(dec) # change type to uint8 for imshow
    return dec
```

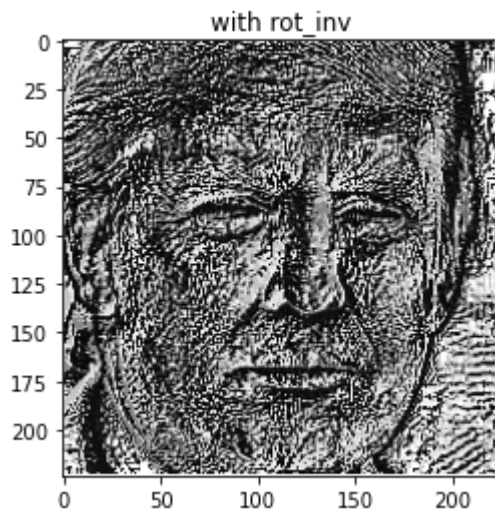
```
In [9]: # Main LBP algorithm
def LBP_Func(src, rot_inv=1):
    v, h = src.shape[0:2]
    dst = src.copy()
    # Set the edge to 255
    dst[0, :]=255
    dst[:, 0]=255
    dst[h-1, :]=255
    dst[:, v-1]=255
    for i in range(1, v-1):
        for j in range(1, h-1):
            dst[i, j] = encode(src, i, j, rot_inv)
    return dst
```

有无旋转不变对比

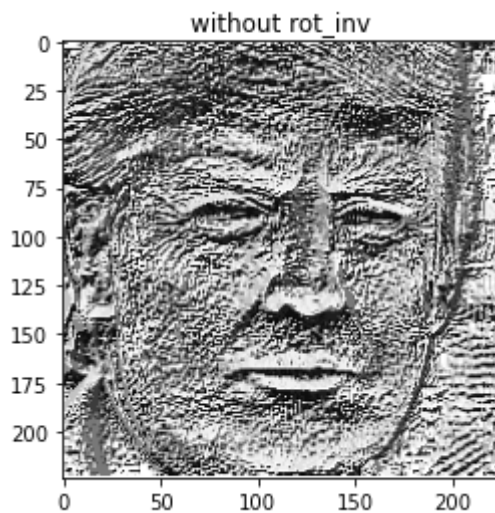
```
In [10]: # With rotational invariance.
n = LBP_Func(G)
# Without rotational invariance.
n2 = LBP_Func(G, 0)
```

```
In [11]: import matplotlib.pyplot as plt
```

```
In [12]: fig = plt.figure()
plt.imshow(n, cmap='gray')
plt.title("with rot_inv")
plt.show()
```



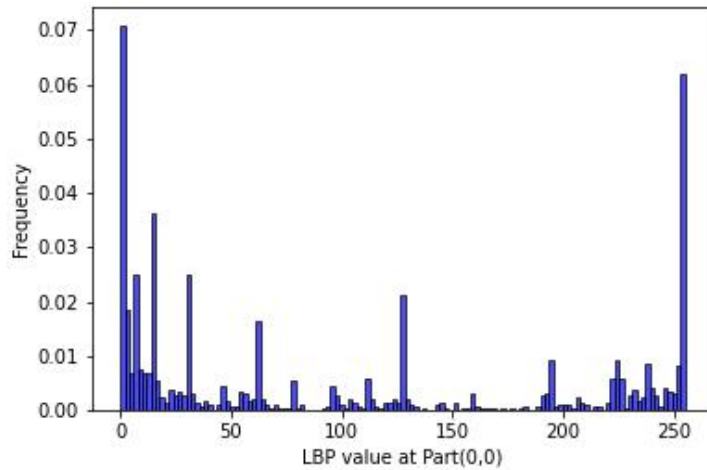
```
In [13]: fig = plt.figure()
plt.imshow(n2, cmap='gray')
plt.title("without rot_inv")
plt.show()
```



直方图

(1)以下均以带有旋转不变性的图片进行计算。将图像分割为7*7个Blocks，从左到右，从上到下，Block边长为56像素，分别计算LBP直方图。

(2)由于直接连接起各个Block的直方图后不好显示，所以使用subplot()的形式，但这样做仍然不够清晰，因此在后面又为每个Block单独绘制了直方图，下面给出了(0,0)部分的示例。文末附件中可以找到各个部分的直方图，同时，附件中也给出了整张图片按照Block分割后的LBP统计特征具体数值。



(3)添加旋转不变性后, LBP可能的数值x一共有129个, 即0和1-255间的所有奇数(保证二进制数最低位为1), 降低了特征维度。

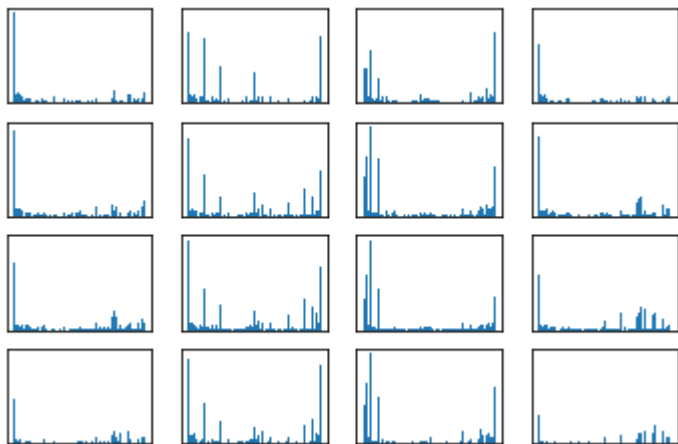
```
In [14]: x=[0]
x.extend(range(1,256,2))
len(x)
```

Out[14]: 129

```
In [15]: # Histograms in one figure.
# Concatenated figure is not so visible in jupyter environment so I used subplot().
LBP = []
Count = 0
plt.figure()

for divV in range(0,224,56):
    for divH in range(0,224,56):

        blockLBP = {}
        block = []
        for i in range(56):
            for j in range(56):
                s = n[divV+i,divH+j]
                block.append(s)
        plt.subplot(4,4,Count+1)
        plt.hist(block,bins=129, density=1)
        plt.xticks([])
        plt.yticks([])
        for k in x:
            #if(block.count(k)>1):
            blockLBP[k] = block.count(k)/56/56
        a = sorted(blockLBP.items(), key=lambda item:item[0])
        Count+=1
        #print(a)
        #print(len(a))
        LBP.append(a)
#plt.savefig('feature.jpg')
```



人脸识别

这一部分采用了直方图加权卡方检验的方法，下面公式中，S为待匹配图像直方图，M为已知图像直方图，其中*i*=0,1,2,...,N为第*i*个Block，*j*=0,1,2,...,128为每个直方图第*j*个LBP数值，*w*为每个Block的权重，在此默认为1/16。则两幅图像的相似性为：

$$\chi_w^2(\mathbf{S}, \mathbf{M}) = \sum_{i,j} w_j \frac{(S_{i,j} - M_{i,j})^2}{S_{i,j} + M_{i,j}},$$

```
In [16]: # Establish the Gallery LBP features.
Gallery=[]
for i in range(5):
    new = cv2.imread(f"./Trump/Trump{i}.jpg", cv2.IMREAD_GRAYSCALE)
    LBP = []
    for divV in range(0, 224, 56):
        for divH in range(0, 224, 56):
            blockLBP = {}
            block = []
            for i in range(56):
                for j in range(56):
                    s = new[divV+i, divH+j]
                    block.append(s)
            for k in x:
                #if(block.count(k)>1):
                blockLBP[k] = block.count(k)/56/56
            a = sorted(blockLBP.items(), key=lambda item:item[0])
            LBP.append(a)
    Gallery.append(LBP)
```

```
In [17]: # For each picture in Gallery, 16 LBP histograms are recorded.
print("Gallery Size :", len(Gallery))
print("Number of Blocks in one image:", len(Gallery[0]))
print("Number of data in each histogram :", len(Gallery[0][0]))
```

```
Gallery Size : 5
Number of Blocks in one image: 16
Number of data in each histogram : 129
```

```
In [18]: # Get the Probe LBP value.
test = cv2.imread("./Trump/Trump0.jpg", cv2.IMREAD_GRAYSCALE)
LBP_test = []
```

```

for divV in range(0,224,56):
    for divH in range(0,224,56):
        blockLBP = {}
        block = []
        for i in range(56):
            for j in range(56):
                s = test[divV+i,divH+j]
                block.append(s)
        for k in x:
            #if(block.count(k)>1):
            blockLBP[k] = block.count(k)/56/56
        a = sorted(blockLBP.items(), key=lambda item:item[0])
        LBP_test.append(a)

```

In [19]: LBP_test[0][0][1] # No.0 Blocks in 16, No.0 Hist-pair in 129, No.1 Data in (x,y)

Out[19]: 0.0

In [20]: Gallery[0][0][0][1] # No.0 Gallery Data, No.0 Blocks in 16, No.0 Hist-pair in 129, No.1 Data in

Out[20]: 0.0

In [21]: # Compute the Similarities and get the minimum.

```

w=[1/32, 1/32, 1/32, 1/32,
    1/32, 5/32, 5/32, 1/32,
    1/32, 5/32, 5/32, 1/32,
    1/32, 1/32, 1/32, 1/32]
chi2 = [] # Chi-square test value
for i in range(5):
    total = 0
    for j in range(16):
        for k in range(129):
            d = LBP_test[j][k][1]-Gallery[i][j][k][1]
            d2 = d*d
            s = LBP_test[j][k][1]+Gallery[i][j][k][1]
            if(s==0):continue
            xw2 = d2/s*w[i]
            total+=xw2
    chi2.append(total)
    print(f"Weighted Chi-2 for No. {i} Gallery-Trump image:",f"{total:.2f}")

```

Weighted Chi-2 for No.0 Gallery-Trump image: 0.00

Weighted Chi-2 for No.1 Gallery-Trump image: 0.20

Weighted Chi-2 for No.2 Gallery-Trump image: 0.14

Weighted Chi-2 for No.3 Gallery-Trump image: 0.17

Weighted Chi-2 for No.4 Gallery-Trump image: 0.22

测试图实际上选取了Trump0.jpg，因此从以上结果可以看出二者完全加权卡方计算结果为0，表明二者匹配。

下面继续添加了Gallery2-Biden进行对比，但进行对比之后就会发现效果不是很好，主要原因还是数据集不标准，图像质量低，无法突出面部细节，例如“瘡子”这样的特征，但整体上已经完成了本次实验的任务，达到学习目的，因此没有继续追求高质量数据。

```

In [22]: Gallery2=[]
for i in range(5):
    new = cv2.imread(f"./Biden/Biden{i}.jpg",cv2.IMREAD_GRAYSCALE)
    LBP = []

```

```

for divV in range(0,224,56):
    for divH in range(0,224,56):
        blockLBP = {}
        block = []
        for i in range(56):
            for j in range(56):
                s = new[divV+i,divH+j]
                block.append(s)
        for k in x:
            #if(block.count(k)>1):
                blockLBP[k] = block.count(k)/56/56
        a = sorted(blockLBP.items(), key=lambda item:item[0])
        LBP.append(a)
Gallery2.append(LBP)

```

```

In [23]: # Compute the Similarities and get the minimum.
w=[1/32, 1/32, 1/32, 1/32,
    1/32, 5/32, 5/32, 1/32,
    1/32, 5/32, 5/32, 1/32,
    1/32, 1/32, 1/32, 1/32]
chi2 = [] # Chi-square test value
for i in range(5):
    total = 0
    for j in range(16):
        for k in range(129):
            d = LBP_test[j][k][1]-Gallery2[i][j][k][1]
            d2 = d*d
            s = LBP_test[j][k][1]+Gallery2[i][j][k][1]
            if(s==0):continue
            xw2 = d2/s*w[i]
            total+=xw2
    chi2.append(total)
    print(f"Weighted Chi-2 for No.{i} Gallery2-Biden image:",f"{total:.2f}")

```

```

Weighted Chi-2 for No.0 Gallery2-Biden image: 0.18
Weighted Chi-2 for No.1 Gallery2-Biden image: 0.33
Weighted Chi-2 for No.2 Gallery2-Biden image: 0.26
Weighted Chi-2 for No.3 Gallery2-Biden image: 0.21
Weighted Chi-2 for No.4 Gallery2-Biden image: 0.16

```

参考文献

[1] [人脸识别经典算法二：LBP方法](#)

[2] [LBP原理介绍以及算法实现](#)

[3] [卡方检验 \(Chi square statistic\)](#)

附件

```

In [24]: # Separate Histograms
LBP = []

```



```

Count = 0
for divV in range(0, 224, 56):
    for divH in range(0, 224, 56):

        blockLBP = {}
        block = []
        for i in range(56):
            for j in range(56):
                s = n[divV+i, divH+j]
                block.append(s)

        plt.figure()
        plt.hist(block, bins=129, density=1, facecolor="blue", edgecolor="black", alpha=0.7)
        plt.xlabel(f"LBP value at Part({Count//4}, {Count%4})")
        plt.ylabel("Frequency") # Normalized
        #plt.show()
        #plt.savefig(f"hist{Count}.jpg")
        for k in x:
            #if (block.count(k)>1):
                blockLBP[k] = block.count(k)
        a = sorted(blockLBP.items(), key=lambda item:item[0])
        print("-----")
        print(f"LBP Feature at Part({Count//4}, {Count%4}): ", a)
        print("-----")
        #print(len(a))
        Count+=1
        LBP.append(a)

```

LBP Feature at Part(0,0): [(0, 165), (1, 274), (3, 114), (5, 42), (7, 155), (9, 47), (11, 42), (13, 42), (15, 224), (17, 33), (19, 15), (21, 8), (23, 24), (25, 18), (27, 22), (29, 17), (31, 154), (33, 19), (35, 9), (37, 4), (39, 10), (41, 6), (43, 1), (45, 7), (47, 27), (49, 10), (51, 5), (53, 4), (55, 22), (57, 19), (59, 10), (61, 12), (63, 102), (65, 12), (67, 7), (69, 3), (71, 7), (73, 2), (75, 3), (77, 2), (79, 34), (81, 2), (83, 6), (85, 1), (87, 1), (89, 0), (91, 3), (93, 5), (95, 27), (97, 17), (99, 7), (101, 2), (103, 12), (105, 8), (107, 4), (109, 3), (111, 36), (113, 13), (115, 4), (117, 2), (119, 9), (121, 8), (123, 12), (125, 9), (127, 131), (129, 13), (131, 6), (133, 4), (135, 1), (137, 3), (139, 0), (141, 1), (143, 7), (145, 9), (147, 2), (149, 0), (151, 8), (153, 0), (155, 3), (157, 3), (159, 20), (161, 5), (163, 3), (165, 2), (167, 3), (169, 3), (171, 0), (173, 2), (175, 0), (177, 3), (179, 0), (181, 3), (183, 4), (185, 1), (187, 0), (189, 5), (191, 16), (193, 20), (195, 57), (197, 5), (199, 7), (201, 7), (203, 6), (205, 2), (207, 14), (209, 9), (211, 7), (213, 1), (215, 4), (217, 4), (219, 1), (221, 9), (223, 37), (225, 57), (227, 36), (229, 3), (231, 17), (233, 23), (235, 11), (237, 14), (239, 53), (241, 25), (243, 17), (245, 5), (247, 25), (249, 22), (251, 19), (253, 50), (255, 384)]

LBP Feature at Part(0,1): [(0, 118), (1, 185), (3, 188), (5, 32), (7, 251), (9, 30), (11, 30), (13, 37), (15, 386), (17, 15), (19, 19), (21, 0), (23, 23), (25, 24), (27, 26), (29, 20), (31, 277), (33, 3), (35, 8), (37, 1), (39, 13), (41, 0), (43, 2), (45, 8), (47, 31), (49, 8), (51, 12), (53, 4), (55, 14), (57, 10), (59, 11), (61, 13), (63, 158), (65, 3), (67, 2), (69, 0), (71, 11), (73, 2), (75, 0), (77, 5), (79, 17), (81, 0), (83, 1), (85, 0), (87, 1), (89, 0), (91, 2), (93, 0), (95, 16), (97, 4), (99, 4), (101, 2), (103, 13), (105, 3), (107, 2), (109, 8), (111, 31), (113, 6), (115, 4), (117, 0), (119, 9), (121, 10), (123, 11), (125, 15), (127, 130), (129, 15), (131, 12), (133, 3), (135, 23), (137, 2), (139, 1), (141, 5), (143, 31), (145, 3), (147, 3), (149, 0), (151, 1), (153, 2), (155, 5), (157, 6), (159, 31), (161, 1), (163, 1), (165, 1), (167, 0), (169, 0), (171, 0), (173, 0), (175, 8), (177, 2), (179, 2), (181, 0), (183, 2), (185, 3), (187, 2), (189, 2), (191, 45), (193, 20), (195, 13), (197, 1), (199, 14), (201, 4), (203, 2), (205, 4), (207, 28), (209, 3), (211, 2), (213, 0), (215, 4), (217, 1), (219, 4), (221, 2), (223, 32), (225, 10), (227, 10), (229, 2), (231, 20), (233, 2), (235, 1), (237, 6), (239, 47), (241, 24), (243, 26), (245, 1), (247, 24), (249, 28), (251, 17), (253, 21), (255, 282)]

LBP Feature at Part(0,2): [(0, 156), (1, 269), (3, 159), (5, 37), (7, 166), (9, 31), (11, 33), (13, 54), (15, 243), (17, 27), (19, 18), (21, 5), (23, 14), (25, 13), (27, 20), (29, 11), (31, 117), (33, 15), (35, 11), (37, 8), (39, 25), (41, 8), (43, 1), (45, 10), (47, 32), (49, 10), (51, 6), (53, 3), (55, 18), (57, 13), (59, 11), (61, 13), (63, 72), (65, 9), (67, 15), (69, 3), (71, 9), (73, 2), (75, 2), (77, 1), (79, 11), (81, 1), (83, 0), (85, 1), (87, 3), (89, 2), (91, 1), (93, 0), (95, 7), (97, 5), (99, 8), (101, 2), (103, 15), (105, 7), (107, 2), (109, 6), (111, 39), (113, 3), (115, 8), (117, 3), (119, 19), (121, 26), (123, 16), (125, 22), (127, 90), (129, 13), (131, 20), (133, 6), (135, 44), (137, 8), (139, 5), (141, 15), (143, 96), (145, 9), (147, 5), (149, 0), (151, 5), (153, 2), (155, 7), (157, 4), (159, 55), (161, 3), (163, 2), (165, 0), (167, 7), (169, 1), (171, 1), (173, 3), (175, 19), (177, 2), (179, 3), (181, 0), (183, 8), (185, 1), (187, 3), (189, 4), (191, 42), (193, 15), (195, 21), (197, 4), (199, 31), (201, 2), (203, 4), (205, 2), (207, 47), (209, 4), (211, 2), (213, 0), (215, 7), (217, 2), (219, 10), (221, 2), (223, 25), (225, 9), (227, 19), (229, 6), (231, 25), (233, 3), (235, 4), (237, 3), (239, 67), (241, 16), (243, 23), (245, 4), (247, 38), (249, 13), (251, 30), (253, 8), (255, 330)]

LBP Feature at Part(0,3): [(0, 107), (1, 199), (3, 104), (5, 45), (7, 223), (9, 35), (11, 20), (13, 40), (15, 359), (17, 17), (19, 12), (21, 6), (23, 17), (25, 16), (27, 16), (29, 14), (31, 242), (33, 5), (35, 10), (37, 1), (39, 12), (41, 10), (43, 6), (45, 8), (47, 25), (49, 1), (51, 7), (53, 0), (55, 11), (57, 17), (59, 12), (61, 26), (63, 125), (65, 4), (67, 6), (69, 3), (71, 5), (73, 4), (75, 4), (77, 2), (79, 4), (81, 1), (83, 0), (85, 0), (87, 2), (89, 3), (91, 0), (93, 4), (95, 9), (97, 2), (99, 5), (101, 2), (103, 14), (105, 11), (107, 0), (109, 10), (111, 21), (113, 5), (115, 4), (117, 0), (119, 14), (121, 19), (123, 19), (125, 21), (127, 118), (129, 12), (131, 22), (133, 7), (135, 48), (137, 4), (139, 2), (141, 9), (143, 36), (145, 3), (147, 4), (149, 2), (151, 8), (153, 2), (155, 2), (157, 2), (159, 22), (161, 0), (163, 0), (165, 2), (167, 8), (169, 1), (171, 0), (173, 3), (175, 8), (177, 2), (179, 1), (181, 0), (183, 3), (185, 2), (187, 3), (189, 2), (191, 33), (193, 6), (195, 24), (197, 1), (199, 29), (201, 0), (203, 2), (205, 2), (207, 28), (209, 2), (211, 2), (213, 0), (215, 3), (217, 4), (219, 3), (221, 6), (223, 27), (225, 8), (227, 10), (229, 1), (231, 19), (233, 2), (235, 0), (237, 2), (239, 21), (241, 11), (243, 10), (245, 3), (247, 33), (249, 26), (251, 37), (253, 31), (255, 466)]

LBP Feature at Part(1,0): [(0, 119), (1, 221), (3, 169), (5, 32), (7, 249), (9, 32), (11, 32), (13, 30), (15, 355), (17, 22), (19, 15), (21, 2), (23, 16), (25, 14), (27, 17), (29, 13), (31, 260), (33, 11), (35, 5), (37, 2), (39, 6), (41, 6), (43, 3), (45, 3), (47, 18), (49, 14), (51, 7), (53, 5), (55, 8), (57, 10), (59, 12), (61, 18), (63, 160), (65, 4), (67, 6), (69, 1), (71, 4), (73, 3), (75, 3), (77, 2), (79, 8), (81, 1), (83, 3), (85, 1), (87, 1), (89, 2), (91, 1), (93, 1), (95, 14), (97, 15), (99, 5), (101, 1), (103, 6), (105, 7), (107, 3), (109, 3), (111, 1), (113, 11), (115, 7), (117, 1), (119, 10), (121, 17), (123, 11), (125, 17), (127, 79), (129, 19), (131, 25), (133, 4), (135, 42), (137, 5), (139, 1), (141, 3), (143, 30), (145, 1), (147, 2), (149, 0), (151, 5), (153, 2), (155, 0), (157, 3), (159, 36), (161, 3), (163, 1), (165, 1), (167, 5), (169, 0), (171, 0), (173, 1), (175, 4), (177, 4), (179, 6), (181, 0), (183, 7), (185, 4), (187, 0), (189, 9), (191, 45), (193, 20), (195, 22), (197, 2), (199, 38), (201, 6), (203, 2), (205, 0), (207, 18), (209, 4), (211, 0), (213, 0), (215, 0), (217, 2), (219, 1), (221, 3), (223, 15), (225, 33), (227, 24), (229, 2), (231, 18), (233, 12), (235, 7), (237, 7), (239, 39), (241, 20), (243, 21), (245, 2), (247, 23), (249, 41), (251, 39), (253, 61), (255, 241)]

LBP Feature at Part(1,1): [(0, 118), (1, 214), (3, 143), (5, 27), (7, 219), (9, 30), (11, 18), (13, 24), (15, 380), (17, 27), (19, 10), (21, 2), (23, 14), (25, 14), (27, 12), (29, 12), (31, 172), (33, 16), (35, 9), (37, 2), (39, 10), (41, 4), (43, 1), (45, 1), (47, 17), (49, 10), (51, 4), (53, 2), (55, 12), (57, 7), (59, 12), (61, 5), (63, 84), (65, 7), (67, 2), (69, 3), (71, 8), (73, 2), (75, 1), (77, 2), (79, 19), (81, 2), (83, 2), (85, 0), (87, 3), (89, 0), (91, 4), (93, 1), (95, 8), (97, 11), (99, 9), (101, 4), (103, 10), (105, 8), (107, 1), (109, 3), (111, 1), (113, 9), (115, 4), (117, 0), (119, 16), (121, 19), (123, 13), (125, 16), (127, 102), (129, 29), (131, 14), (133, 0), (135, 30), (137, 10), (139, 2), (141, 4), (143, 52), (145, 7), (147, 3), (149, 0), (151, 3), (153, 4), (155, 0), (157, 5), (159, 36), (161, 1), (163, 2), (165, 0), (167, 4), (169, 1), (171, 1), (173, 0), (175, 5), (177, 3), (179, 4), (181, 0), (183, 3), (185, 3), (187, 3), (189, 5), (191, 21), (193, 62), (195, 41), (197, 3), (199, 22), (201, 5), (203, 2), (205, 1), (207, 35), (209, 5), (211, 4), (213, 1), (215, 2), (217, 4), (219, 4), (221, 4), (223, 38), (225, 115), (227, 43), (229, 8), (231, 42), (233, 4), (235, 7), (237, 7), (239, 80), (241, 83), (243, 25), (245, 6), (247, 30), (249, 24), (251, 27), (253, 21), (255, 192)]

LBP Feature at Part(1,2): [(0, 113), (1, 209), (3, 156), (5, 29), (7, 231), (9, 24), (11, 25), (13, 16), (15, 349), (17, 21), (19, 18), (21, 3), (23, 14), (25, 14), (27, 13), (29, 14), (31, 222), (33, 18), (35, 4), (37, 1), (39, 8), (41, 1), (43, 1), (45, 1), (47, 23), (49, 8), (51, 4), (53, 2), (55, 11), (57, 11), (59, 4), (61, 21), (63, 112), (65, 10), (67, 15), (69, 0), (71, 5), (73, 0), (75, 2), (77, 1), (79, 11), (81, 4), (83, 1), (85, 0), (87, 3), (89, 2), (91, 1), (93, 2), (95, 6), (97, 15), (99, 7), (101, 2), (103, 8), (105, 3), (107, 1), (109, 0), (111, 1), (113, 14), (115, 10), (117, 7), (119, 12), (121, 13), (123, 5), (125, 9), (127, 68), (129, 9), (131, 15), (133, 30), (135, 102), (137, 3), (139, 0), (141, 1), (143, 36), (145, 1), (147, 5), (149, 0), (151, 6), (153, 4), (155, 4), (157, 3), (159, 17), (161, 5), (163, 7), (165, 0), (167, 5), (169, 3), (171, 0), (173, 0), (175, 4), (177, 3), (179, 1), (181, 0), (183, 3), (185, 0), (187, 7), (189, 5), (191, 41), (193, 26), (195, 76), (197, 8), (199, 60), (201, 3), (203, 4), (205, 1), (207, 19), (209, 4), (211, 5), (213, 0), (215, 2), (217, 4), (219, 3), (221, 1), (223, 7), (225, 20), (227, 77), (229, 34), (229, 6), (231, 28), (233, 14), (235, 10), (237, 5), (239, 39), (241, 42), (243, 55), (245, 31), (247, 7), (247, 28), (249, 31), (251, 41), (253, 40), (255, 19)]

LBP Feature at Part(1,3): [(0, 108), (1, 222), (3, 127), (5, 21), (7, 166), (9, 21), (11, 21), (13, 22), (15, 372), (17, 34), (19, 11), (21, 3), (23, 19), (25, 17), (27, 16), (29, 20), (31, 195), (33, 16), (35, 7), (37, 2), (39, 10), (41, 4), (43, 2), (45, 4), (47, 11), (49, 7), (51, 11), (53, 3), (55, 6), (57, 12), (59, 2), (61, 16), (63, 105), (65, 7), (67, 3), (69, 2), (71, 11), (73, 1), (75, 2), (77, 3), (79, 10), (81, 2), (83, 2), (85, 0), (87, 0), (89, 1), (91, 2), (93, 2), (95, 8), (97, 9), (99, 8), (101, 0), (103, 8), (105, 1), (107, 0), (109, 4), (111, 8), (113, 7), (115, 7), (117, 1), (119, 10), (121, 15), (123, 9), (125, 16), (127, 69), (129, 10), (131, 53), (133, 15), (135, 99), (137, 4), (139, 9), (141, 7), (143, 22), (145, 2), (147, 6), (149, 1), (151, 2), (153, 1), (155, 1), (157, 4), (159, 21), (161, 2), (163, 4), (165, 2), (167, 7), (169, 1), (171, 3), (173, 1), (175, 3), (177, 0), (179, 1), (181, 0), (183, 7), (185, 5), (187, 11), (189, 10), (191, 53), (193, 21), (195, 71), (197, 3), (199, 83), (201, 2), (203, 5), (205, 1), (207, 22), (209, 1), (211, 6), (213, 0), (215, 4), (217, 4), (219, 8), (221, 5),

(223, 15), (225, 31), (227, 12), (229, 2), (231, 32), (233, 1), (235, 5), (237, 1), (239, 25), (241, 48), (243, 37), (245, 7), (247, 26), (249, 34), (251, 66), (253, 34), (255, 315)]

LBP Feature at Part(2,0): [(0, 82), (1, 184), (3, 175), (5, 17), (7, 274), (9, 18), (11, 27), (13, 11), (15, 361), (17, 19), (19, 6), (21, 2), (23, 15), (25, 19), (27, 16), (29, 22), (31, 209), (33, 14), (35, 12), (37, 2), (39, 4), (41, 2), (43, 0), (45, 1), (47, 13), (49, 12), (51, 7), (53, 0), (55, 11), (57, 9), (59, 11), (61, 22), (63, 99), (65, 5), (67, 6), (69, 0), (71, 8), (73, 0), (75, 1), (77, 1), (79, 3), (81, 0), (83, 0), (85, 0), (87, 0), (89, 1), (91, 0), (93, 0), (95, 3), (97, 9), (99, 6), (101, 0), (103, 4), (105, 0), (107, 0), (109, 3), (111, 7), (113, 3), (115, 3), (117, 2), (119, 7), (121, 7), (123, 15), (125, 8), (127, 60), (129, 15), (131, 35), (133, 8), (135, 126), (137, 2), (139, 1), (141, 5), (143, 69), (145, 1), (147, 2), (149, 1), (151, 3), (153, 4), (155, 5), (157, 4), (159, 29), (161, 2), (163, 2), (165, 2), (167, 10), (169, 0), (171, 1), (173, 0), (175, 9), (177, 5), (179, 4), (181, 0), (183, 9), (185, 6), (187, 4), (189, 4), (191, 54), (193, 34), (195, 77), (197, 3), (199, 56), (201, 2), (203, 5), (205, 5), (207, 18), (209, 3), (211, 4), (213, 0), (215, 2), (217, 5), (219, 9), (221, 1), (223, 20), (225, 43), (227, 30), (229, 2), (231, 29), (233, 5), (235, 4), (237, 3), (239, 36), (241, 28), (243, 35), (245, 3), (247, 15), (249, 46), (251, 63), (253, 32), (255, 258)]

LBP Feature at Part(2,1): [(0, 131), (1, 204), (3, 163), (5, 28), (7, 200), (9, 28), (11, 23), (13, 21), (15, 233), (17, 13), (19, 17), (21, 2), (23, 16), (25, 23), (27, 15), (29, 16), (31, 150), (33, 8), (35, 9), (37, 5), (39, 14), (41, 7), (43, 1), (45, 4), (47, 19), (49, 14), (51, 7), (53, 4), (55, 20), (57, 12), (59, 7), (61, 12), (63, 96), (65, 13), (67, 8), (69, 1), (71, 3), (73, 1), (75, 2), (77, 2), (79, 6), (81, 2), (83, 1), (85, 0), (87, 2), (89, 6), (91, 0), (93, 1), (95, 8), (97, 8), (99, 7), (101, 2), (103, 8), (105, 3), (107, 1), (109, 2), (111, 10), (113, 12), (115, 13), (117, 1), (119, 17), (121, 8), (123, 11), (125, 8), (127, 70), (129, 22), (131, 17), (133, 6), (135, 31), (137, 2), (139, 2), (141, 5), (143, 26), (145, 7), (147, 0), (149, 0), (151, 1), (153, 2), (155, 6), (157, 7), (159, 25), (161, 6), (163, 7), (165, 0), (167, 8), (169, 2), (171, 0), (173, 1), (175, 7), (177, 2), (179, 7), (181, 0), (183, 4), (185, 3), (187, 5), (189, 7), (191, 35), (193, 59), (195, 99), (197, 4), (199, 35), (201, 11), (203, 8), (205, 1), (207, 25), (209, 3), (211, 7), (213, 0), (215, 3), (217, 4), (219, 9), (221, 4), (223, 19), (225, 118), (227, 73), (229, 3), (231, 37), (233, 6), (235, 2), (237, 8), (239, 54), (241, 83), (243, 42), (245, 4), (247, 28), (249, 67), (251, 41), (253, 30), (255, 237)]

LBP Feature at Part(2,2): [(0, 100), (1, 173), (3, 166), (5, 20), (7, 290), (9, 17), (11, 22), (13, 22), (15, 475), (17, 7), (19, 13), (21, 4), (23, 14), (25, 15), (27, 11), (29, 14), (31, 214), (33, 13), (35, 10), (37, 0), (39, 10), (41, 1), (43, 3), (45, 2), (47, 8), (49, 7), (51, 7), (53, 1), (55, 13), (57, 11), (59, 9), (61, 16), (63, 98), (65, 2), (67, 12), (69, 4), (71, 8), (73, 1), (75, 0), (77, 2), (79, 14), (81, 3), (83, 2), (85, 0), (87, 1), (89, 0), (91, 1), (93, 6), (95, 11), (97, 8), (99, 3), (101, 0), (103, 7), (105, 0), (107, 5), (109, 2), (111, 13), (113, 3), (115, 8), (117, 0), (119, 13), (121, 9), (123, 19), (125, 13), (127, 83), (129, 20), (131, 27), (133, 5), (135, 53), (137, 0), (139, 2), (141, 4), (143, 37), (145, 3), (147, 3), (149, 0), (151, 2), (153, 1), (155, 4), (157, 6), (159, 27), (161, 3), (163, 1), (165, 2), (167, 10), (169, 1), (171, 0), (173, 1), (175, 2), (177, 4), (179, 1), (181, 1), (183, 10), (185, 5), (187, 2), (189, 8), (191, 31), (193, 33), (195, 36), (197, 4), (199, 32), (201, 2), (203, 8), (205, 1), (207, 27), (209, 4), (211, 3), (213, 1), (215, 2), (217, 3), (219, 6), (221, 2), (223, 16), (225, 91), (227, 27), (229, 4), (231, 24), (233, 6), (235, 2), (237, 6), (239, 29), (241, 101), (243, 36), (245, 9), (247, 18), (249, 40), (251, 39), (253, 33), (255, 176)]

LBP Feature at Part(2,3): [(0, 78), (1, 153), (3, 101), (5, 18), (7, 131), (9, 13), (11, 16), (13, 20), (15, 292), (17, 18), (19, 19), (21, 1), (23, 17), (25, 9), (27, 6), (29, 12), (31, 162), (33, 13), (35, 7), (37, 0), (39, 17), (41, 0), (43, 2), (45, 3), (47, 9), (49, 10), (51, 4), (53, 2), (55, 4), (57, 5), (59, 6), (61, 9), (63, 80), (65, 7), (67, 8), (69, 2), (71, 3), (73, 4), (75, 2), (77, 1), (79, 7), (81, 1), (83, 2), (85, 0), (87, 2), (89, 1), (91, 3), (93, 3), (95, 12), (97, 7), (99, 7), (101, 1), (103, 9), (105, 2), (107, 3), (109, 1), (111, 9), (113, 8), (115, 3), (117, 0), (119, 8), (121, 5), (123, 11), (125, 9), (127, 52), (129, 37), (131, 31), (133, 7), (135, 56), (137, 3), (139, 2), (141, 3), (143, 88), (145, 6), (147, 6), (149, 1), (151, 8), (153, 3), (155, 5), (157, 5), (159, 72), (161, 0), (163, 0), (165, 0), (167, 9), (169, 0), (171, 0), (173, 0), (175, 8), (177, 1), (179, 3), (181, 0), (183, 5), (185, 4), (187, 5), (189, 5), (191, 51), (193, 63), (195, 74), (197, 6), (199, 95), (201, 2), (203, 5), (205,

2), (207, 86), (209, 8), (211, 7), (213, 2), (215, 6), (217, 1), (219, 7), (221, 4), (223, 63), (225, 44), (227, 72), (229, 4), (231, 60), (233, 1), (235, 4), (237, 1), (239, 55), (241, 45), (243, 63), (245, 1), (247, 39), (249, 15), (251, 52), (253, 24), (255, 371)]

LBP Feature at Part(3,0): [(0, 71), (1, 145), (3, 105), (5, 25), (7, 207), (9, 11), (11, 27), (13, 18), (15, 433), (17, 5), (19, 18), (21, 3), (23, 18), (25, 10), (27, 11), (29, 15), (31, 205), (33, 10), (35, 9), (37, 3), (39, 14), (41, 3), (43, 5), (45, 0), (47, 12), (49, 6), (51, 6), (53, 1), (55, 8), (57, 6), (59, 6), (61, 20), (63, 107), (65, 7), (67, 14), (69, 1), (71, 7), (73, 3), (75, 2), (77, 0), (79, 9), (81, 0), (83, 0), (85, 0), (87, 2), (89, 2), (91, 1), (93, 0), (95, 10), (97, 7), (99, 7), (101, 2), (103, 5), (105, 0), (107, 1), (109, 1), (111, 8), (113, 2), (115, 1), (117, 1), (119, 5), (121, 3), (123, 10), (125, 12), (127, 76), (129, 13), (131, 23), (133, 8), (135, 168), (137, 1), (139, 4), (141, 8), (143, 75), (145, 1), (147, 5), (149, 0), (151, 10), (153, 2), (155, 2), (157, 5), (159, 29), (161, 0), (163, 3), (165, 0), (167, 9), (169, 0), (171, 0), (173, 1), (175, 10), (177, 0), (179, 2), (181, 0), (183, 9), (185, 2), (187, 1), (189, 3), (191, 46), (193, 26), (195, 56), (197, 7), (199, 33), (201, 3), (203, 8), (205, 3), (207, 48), (209, 1), (211, 1), (213, 0), (215, 3), (217, 0), (219, 7), (221, 4), (223, 56), (225, 24), (227, 23), (229, 0), (231, 30), (233, 1), (235, 1), (237, 5), (239, 34), (241, 19), (243, 18), (245, 4), (247, 32), (249, 30), (251, 35), (253, 36), (255, 406)]

LBP Feature at Part(3,1): [(0, 128), (1, 191), (3, 177), (5, 35), (7, 248), (9, 33), (11, 18), (13, 38), (15, 340), (17, 17), (19, 11), (21, 1), (23, 10), (25, 17), (27, 17), (29, 12), (31, 157), (33, 16), (35, 6), (37, 1), (39, 12), (41, 4), (43, 3), (45, 2), (47, 21), (49, 12), (51, 11), (53, 3), (55, 9), (57, 18), (59, 13), (61, 14), (63, 82), (65, 7), (67, 6), (69, 1), (71, 6), (73, 4), (75, 4), (77, 1), (79, 15), (81, 1), (83, 1), (85, 0), (87, 1), (89, 1), (91, 2), (93, 5), (95, 7), (97, 12), (99, 9), (101, 1), (103, 10), (105, 4), (107, 2), (109, 6), (111, 10), (113, 13), (115, 7), (117, 2), (119, 16), (121, 21), (123, 21), (125, 13), (127, 64), (129, 20), (131, 17), (133, 3), (135, 35), (137, 4), (139, 2), (141, 5), (143, 48), (145, 5), (147, 2), (149, 0), (151, 6), (153, 8), (155, 7), (157, 6), (159, 24), (161, 6), (163, 3), (165, 1), (167, 3), (169, 0), (171, 1), (173, 3), (175, 8), (177, 6), (179, 5), (181, 0), (183, 4), (185, 4), (187, 1), (189, 7), (191, 23), (193, 27), (195, 15), (197, 2), (199, 14), (201, 4), (203, 3), (205, 1), (207, 34), (209, 8), (211, 3), (213, 0), (215, 2), (217, 1), (219, 1), (221, 5), (223, 29), (225, 71), (227, 20), (229, 4), (231, 31), (233, 6), (235, 7), (237, 13), (239, 51), (241, 90), (243, 28), (245, 8), (247, 31), (249, 42), (251, 37), (253, 35), (255, 296)]

LBP Feature at Part(3,2): [(0, 122), (1, 153), (3, 165), (5, 26), (7, 257), (9, 11), (11, 32), (13, 21), (15, 380), (17, 9), (19, 8), (21, 2), (23, 14), (25, 13), (27, 15), (29, 10), (31, 200), (33, 9), (35, 6), (37, 3), (39, 16), (41, 3), (43, 2), (45, 1), (47, 10), (49, 9), (51, 9), (53, 2), (55, 8), (57, 9), (59, 5), (61, 13), (63, 85), (65, 3), (67, 5), (69, 0), (71, 4), (73, 2), (75, 5), (77, 3), (79, 8), (81, 0), (83, 2), (85, 0), (87, 1), (89, 3), (91, 1), (93, 1), (95, 9), (97, 15), (99, 5), (101, 4), (103, 4), (105, 3), (107, 3), (109, 3), (111, 13), (113, 13), (115, 9), (117, 0), (119, 13), (121, 7), (123, 8), (125, 6), (127, 73), (129, 30), (131, 13), (133, 3), (135, 10), (137, 4), (139, 2), (141, 4), (143, 25), (145, 3), (147, 3), (149, 1), (151, 1), (153, 4), (155, 3), (157, 3), (159, 29), (161, 7), (163, 3), (165, 0), (167, 3), (169, 1), (171, 0), (173, 0), (175, 5), (177, 5), (179, 6), (181, 0), (183, 5), (185, 3), (187, 1), (189, 9), (191, 31), (193, 54), (195, 20), (197, 2), (199, 14), (201, 5), (203, 8), (205, 2), (207, 18), (209, 12), (211, 4), (213, 1), (215, 4), (217, 2), (219, 4), (221, 5), (223, 16), (225, 183), (227, 61), (229, 5), (231, 38), (233, 13), (235, 5), (237, 6), (239, 38), (241, 128), (243, 42), (245, 9), (247, 26), (249, 35), (251, 30), (253, 32), (255, 243)]

LBP Feature at Part(3,3): [(0, 55), (1, 112), (3, 77), (5, 13), (7, 121), (9, 14), (11, 8), (13, 7), (15, 193), (17, 14), (19, 17), (21, 2), (23, 17), (25, 9), (27, 10), (29, 5), (31, 135), (33, 12), (35, 7), (37, 0), (39, 12), (41, 4), (43, 1), (45, 2), (47, 8), (49, 7), (51, 9), (53, 0), (55, 9), (57, 4), (59, 8), (61, 9), (63, 66), (65, 13), (67, 3), (69, 4), (71, 7), (73, 0), (75, 1), (77, 1), (79, 12), (81, 1), (83, 1), (85, 1), (87, 2), (89, 0), (91, 1), (93, 1), (95, 6), (97, 10), (99, 7), (101, 1), (103, 5), (105, 3), (107, 2), (109, 1), (111, 4), (113, 4), (115, 14), (117, 1), (119, 9), (121, 2), (123, 7), (125, 7), (127, 73), (129, 34), (131, 27), (133, 2), (135, 37), (137, 1), (139, 0), (141, 3), (143, 46), (145, 4), (147, 4), (149, 0), (151, 6), (153, 2), (155, 4), (157, 5), (159, 53), (161, 2), (163, 0), (165, 2), (167, 3), (169, 0), (171, 3), (173, 0), (175, 5), (177, 3), (179, 3), (181, 1), (183, 7), (185, 1), (187,

3), (189, 5), (191, 22), (193, 72), (195, 57), (197, 5), (199, 65), (201, 3), (203, 7), (205, 5), (207, 75), (209, 11), (211, 7), (213, 1), (215, 7), (217, 6), (219, 6), (221, 7), (223, 6 3), (225, 115), (227, 108), (229, 3), (231, 90), (233, 9), (235, 8), (237, 5), (239, 86), (241, 74), (243, 77), (245, 6), (247, 65), (249, 40), (251, 31), (253, 39), (255, 524)]

