Group Name : Unfiltered Commentary

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In [ ]:

```
import cv2
import numpy as np
import skimage
import imageio
import mpmath
import matplotlib.pyplot as plt
import seaborn as sns
import PIL
from sklearn.cluster import KMeans
from tqdm import tqdm
```

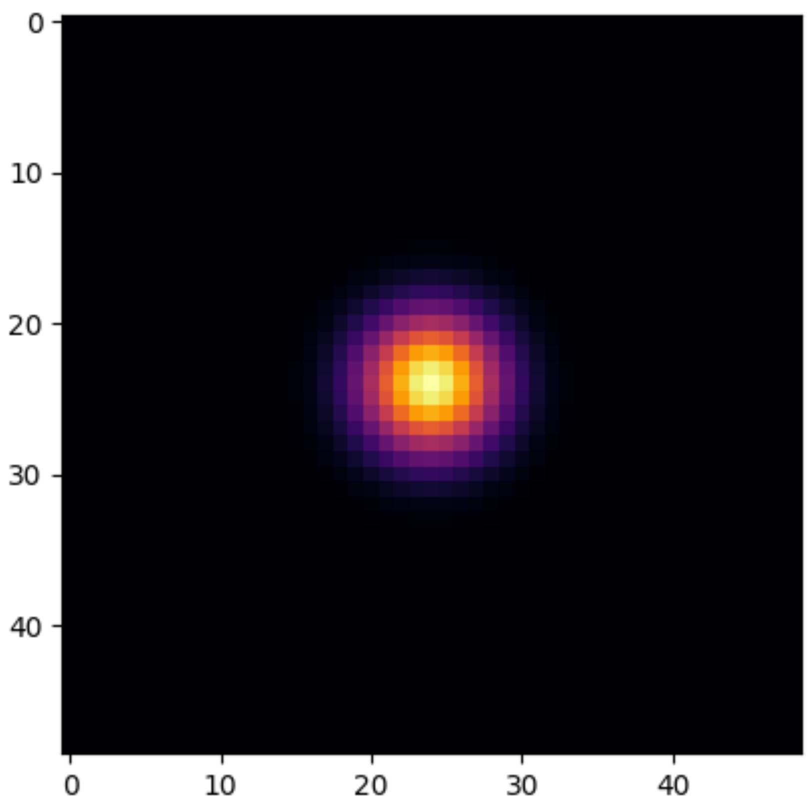
Question 1 Filters

In [ ]:

```
def GaussFilter(size, sigma):
    values =np.arange(-(size//2), size//2 + 1)
    x, y = np.meshgrid(values, values)
    g = (1/(2*np.pi * sigma**2)) * np.exp(-(x**2 + y**2)/(2*sigma**2))
    #normalisng it - sometimes the sum is not perfectly 1...
    g /= np.sum(g)
    # print(np.sum(g))
    return g

test_gauss = GaussFilter(49, 10**0.5)
plt.imshow(test_gauss, cmap="inferno")
```

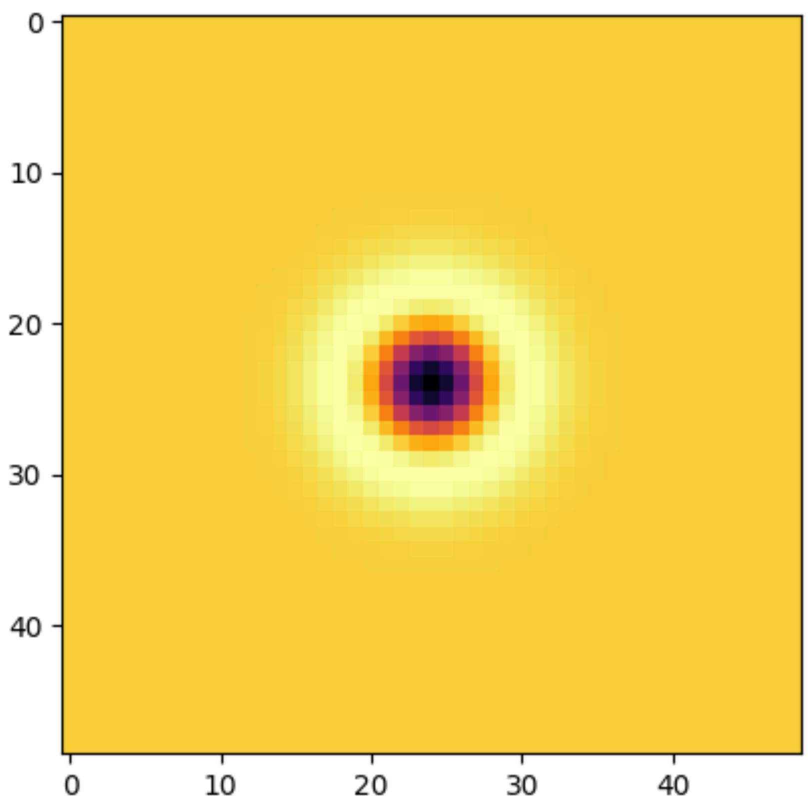
Out[ ]:

```
<matplotlib.image.AxesImage at 0x20c51d10680>
```



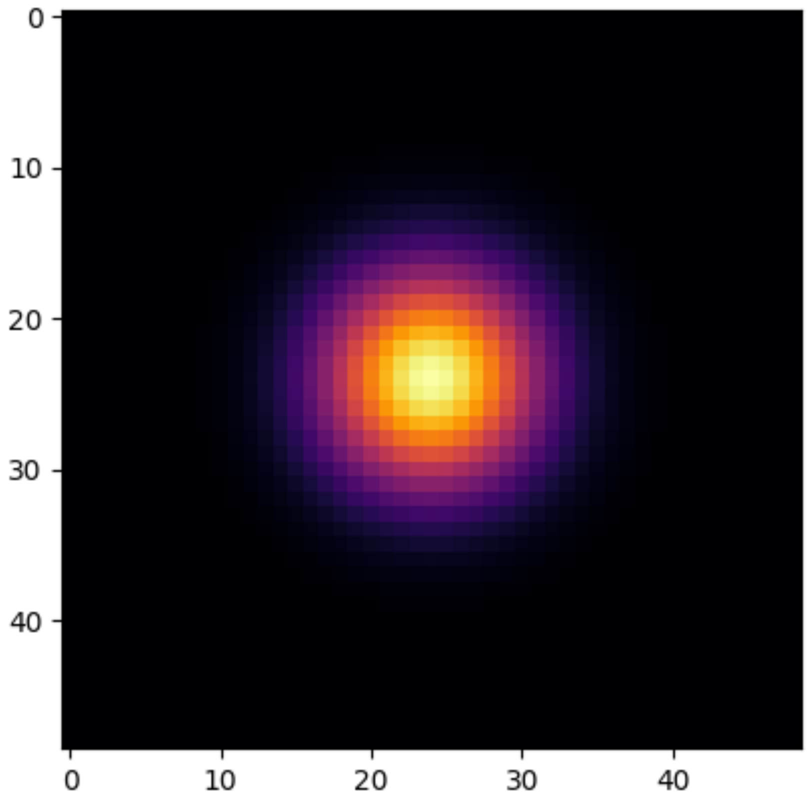
In [ ]:
```
def LoG(size, sigma):
    values =np.arange(-(size//2), size//2 + 1)
    x, y = np.meshgrid(values, values)

    g = -((1)/(np.pi * sigma ** 4 )) * \
        (1- (x**2 + y**2)/(2* sigma **2)) * \
        np.exp(-(x**2 + y**2)/(2*sigma**2))


    return g
test_log = LoG(49, 10**0.5)
plt.imshow(test_log,cmap="inferno")
```

Out[ ]:
```
<matplotlib.image.AxesImage at 0x20c51dfba40>
```



In [ ]:
```
def DoG(size, sigma, K):
    values =np.arange(-(size//2), size//2 + 1)
    x, y = np.meshgrid(values, values)

    g = ((1/(2 * np.pi * sigma **2)) * \
        np.exp(-(x**2 + y ** 2)/(2 * sigma **2))) - \
        ((1/ (2 * np.pi * K**2 *sigma**2)) * \
        np.exp(-(x**2 + y ** 2)/(2 * K**2 * sigma **2)))

    return g


test_dog = DoG(49, 5, 10)
plt.imshow(test_dog,cmap="inferno")
```

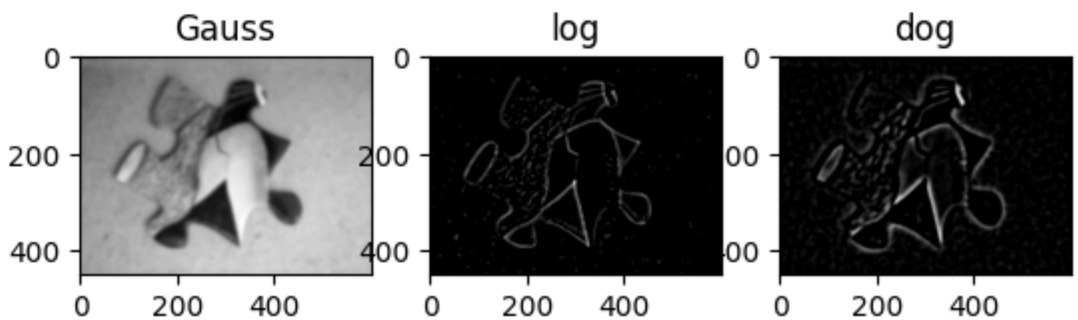
Out[ ]: <matplotlib.image.AxesImage at 0x20c55e332c0>



In [ ]:
```
# Outputs for question 1
gauss = GaussFilter(49, 10**0.5)
lgauss =  LoG(49, 10**0.5)
dgauss = DoG(49,10**0.5,2)

image = cv2.imread('Images/image-35.jpg',cv2.IMREAD_GRAYSCALE)
# get gaussian
gauss = cv2.filter2D(src=image, ddepth=-1, kernel = gauss)

# get log
l_gauss = cv2.filter2D(src=image, ddepth=-1, kernel = lgauss)

# get dog
d_gauss = cv2.filter2D(src=image, ddepth=-1, kernel = dgauss)
```

```
plt.figure()
plt.subplot(1,3,1)
plt.imshow(gauss,cmap='gray')
plt.title("Gauss")

plt.subplot(1,3,2)
plt.imshow(l_gauss,cmap='gray')
plt.title("log")

plt.subplot(1,3,3)
plt.imshow(d_gauss,cmap='gray')
plt.title("dog")
```

Out[ ]: Text(0.5, 1.0, 'dog')



Question 2

In [ ]:
```
from scipy.ndimage import convolve

def create_gaussian_filter(theta, sigma_x, sigma_y, size, filter_type='edge'):
    # Create a grid of (x, y) coordinates
    x = np.linspace(-size//2+1, size//2, size)
    y = np.linspace(-size//2+1, size//2, size)
    x, y = np.meshgrid(x, y)
    # Rotate the coordinates
    x_rot = x * np.cos(theta) + y * np.sin(theta)
    y_rot = -x * np.sin(theta) + y * np.cos(theta)

    # Calculate the Gaussian function f(xrot,sigmax)*f(yrot,sigmay)
    fx = np.exp(-0.5 * (x_rot**2 / sigma_x**2))/(np.sqrt(2 * np.pi) * sigma_x)
    fy = np.exp(-0.5 * (y_rot**2 / sigma_y**2))/(np.sqrt(2 * np.pi) * sigma_y)
```

```python
    if filter_type == 'edge':
        # First derivative (edge)
        #x'
        dG_dx = fy*fx*(-x_rot/sigma_x**2)
        #y'
        dG_dy = fx*fy*(-y_rot/sigma_y**2)
        return dG_dx, dG_dy

    elif filter_type == 'bar':
        # Second derivative (bar)
        #x'
        d2G_dx2 = fy*fx*((x_rot**2-sigma_x**2)/sigma_x**4)
        #y'
        d2G_dy2 = fx*fy*((y_rot**2-sigma_y**2)/sigma_y**4)
        return d2G_dx2, d2G_dy2
    else:
        raise ValueError("Unknown filter type. Use 'edge' or 'bar'.")

def construct_rfs(debug: bool = False):
    sigma_x_sigma_y = np.array([(3,1),(6,2),(12,4)])
    thetas = np.array([0, 1/6*np.pi, 2/6*np.pi, 3/6*np.pi, 4/6*np.pi, 5/6*np.pi])

    size = (49, 49)

    rfs_edge = np.zeros((sigma_x_sigma_y.shape[0], thetas.shape[0], size[0], size[1]))
    rfs_bar = np.zeros((sigma_x_sigma_y.shape[0], thetas.shape[0], size[0], size[1]))

    for sigma_ind in range(sigma_x_sigma_y.shape[0]):
        for theta_ind in range(thetas.shape[0]):
            sigma = sigma_x_sigma_y[sigma_ind]
            theta = thetas[theta_ind]

            gaussian_edge = create_gaussian_filter(theta, sigma[0], sigma[1], size[0], 'edge')
            rfs_edge[sigma_ind, theta_ind] = gaussian_edge[1]
            gaussian_bar = create_gaussian_filter(theta, int(sigma[0]), sigma[1], size[0], 'bar')
            rfs_bar[sigma_ind, theta_ind] = gaussian_bar[1]

    # Combine rfs_edge and rfs_bar by concatenating along the theta axis
    rfs_combined = np.concatenate((rfs_edge, rfs_bar), axis=0)

    print(rfs_combined.shape)
```

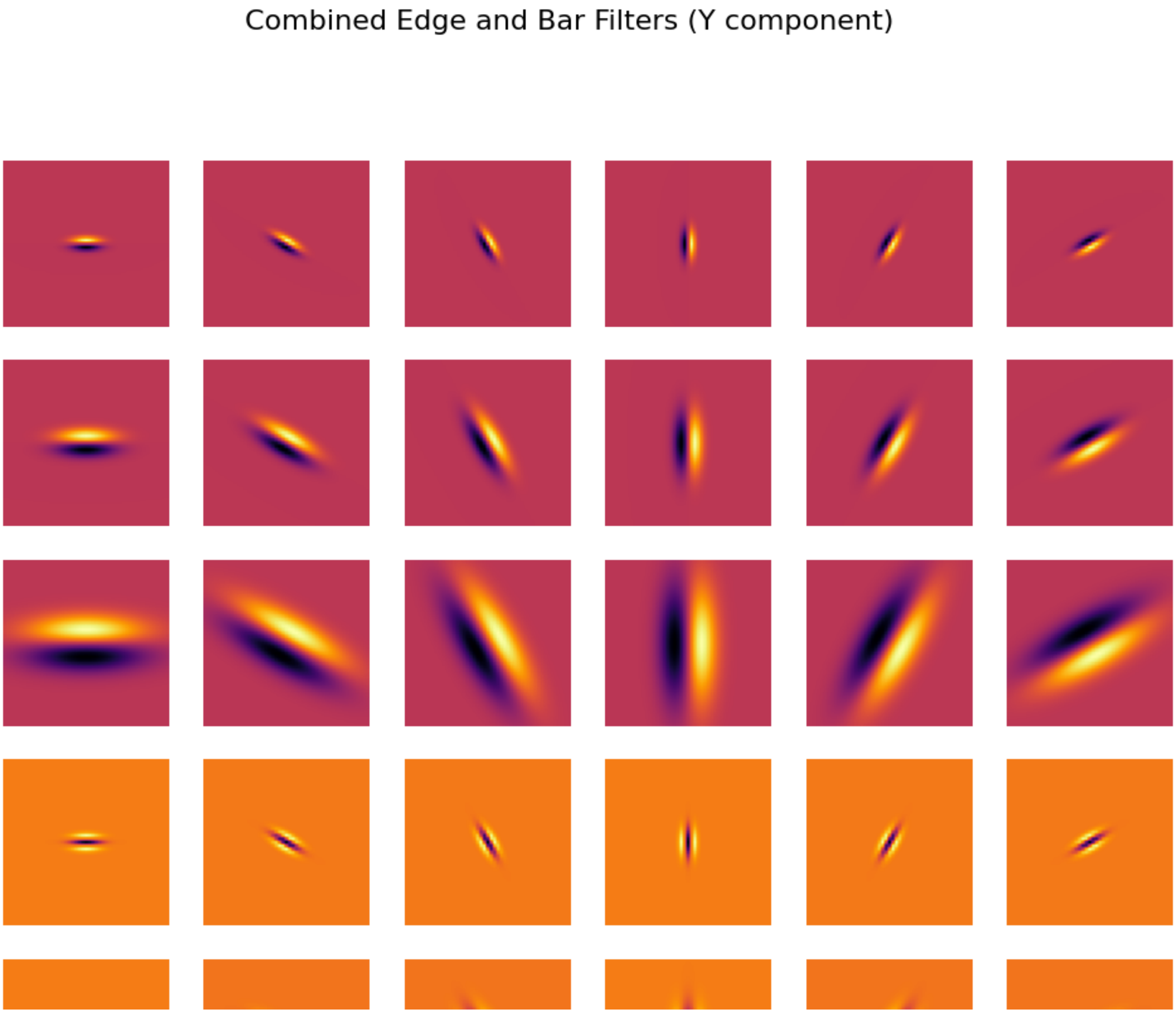
```
    def plot_filters(filters, title, size=(49, 49)):
        rows, cols = filters.shape[:2]
        fig, axes = plt.subplots(rows, cols, figsize=(12, 12))
        fig.suptitle(title, fontsize=16)

        for i in range(rows):
            for j in range(cols):
                ax = axes[i, j]
                ax.imshow(filters[i, j], cmap='inferno')
                ax.axis('off')

        plt.show()

    if debug:
        plot_filters(rfs_combined, title="Combined Edge and Bar Filters (Y component)")

    return rfs_combined

def apply_rfs_filter_scipy(image, rfs_filters):
    max_responses = np.zeros((image.shape[0], image.shape[1], rfs_filters.shape[0] +2)) # plus 2 for the log and gaus

    for sigma_ind in range(rfs_filters.shape[0]):
        # Edge filters
        responses = []
        for theta_ind in range(rfs_filters.shape[1]):
            filter = rfs_filters[sigma_ind, theta_ind]
            response = convolve(image, filter)
            responses.append(response)

        max_responses[:, :, sigma_ind] = np.max(responses, axis=0)
    # now apply log and gauss and add them to the responses at the end of np array
    sigma = 10**0.5

    log_response = convolve(image,LoG(49, sigma))
    gauss_response = convolve(image,GaussFilter(49, sigma))
    max_responses[:,:,max_responses.shape[2]-2] = gauss_response
    max_responses[:,:,max_responses.shape[2]-1] = log_response

    return max_responses
```

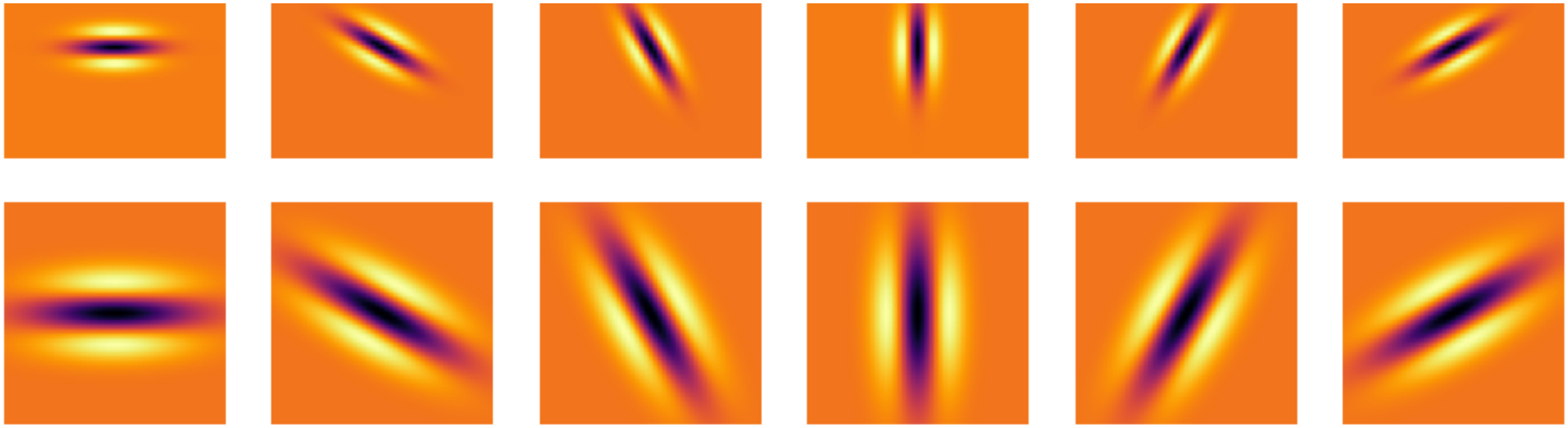
In [ ]:

```
mr8_image = cv2.imread("Images/image-35.jpg", cv2.IMREAD_GRAYSCALE)
# print(mr8_image.shape)
```

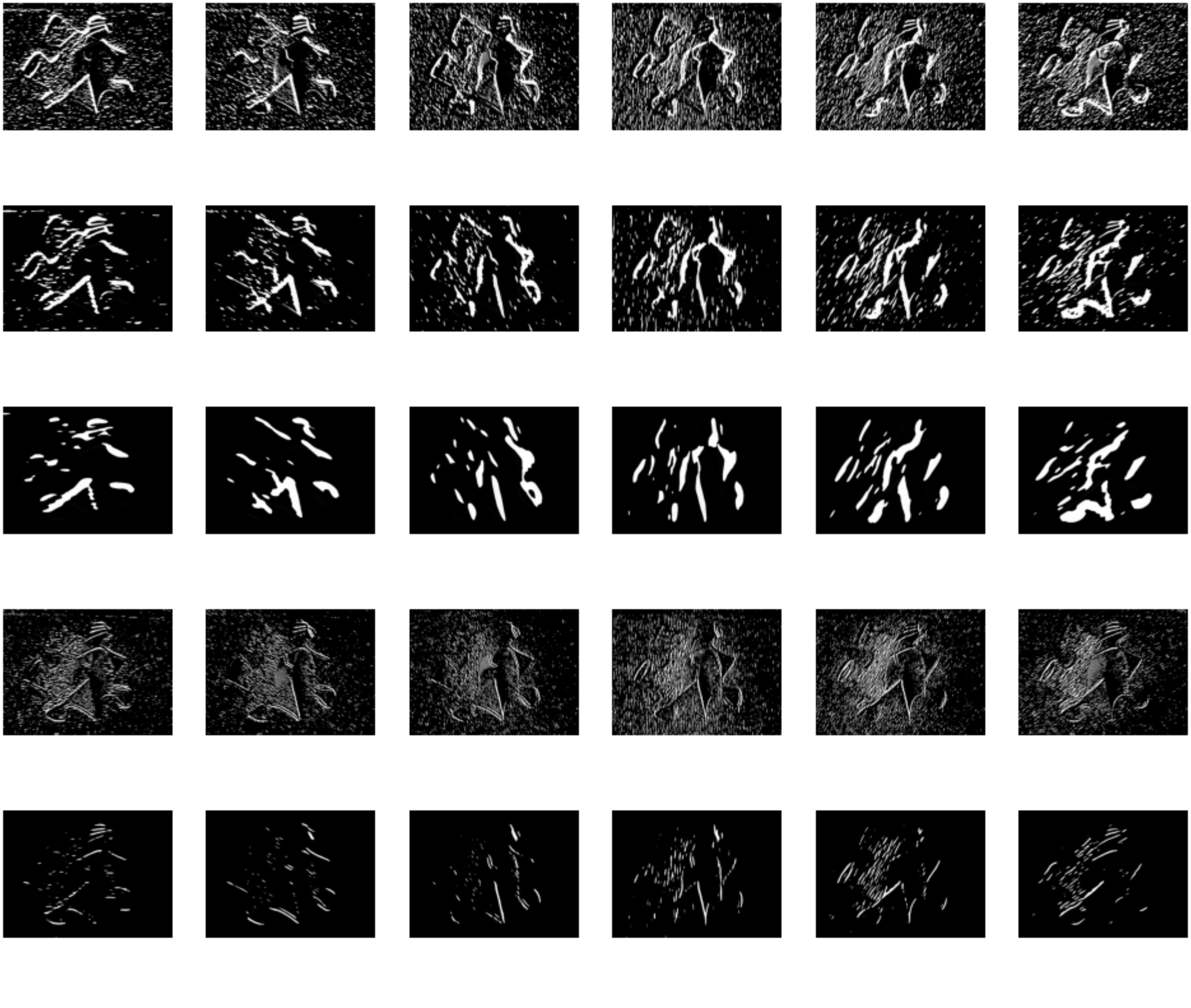
```
rfs_filters = construct_rfs(debug=True)

responses = []
for sigma_ind in range(rfs_filters.shape[0]):
    for theta_ind in range(rfs_filters.shape[1]):
        response = convolve(mr8_image,rfs_filters[sigma_ind, theta_ind])
        responses.append(response)


print("count",len(responses))
rows = 6
cols = 6
fig, axes = plt.subplots(rows, cols, figsize=(12, 12))

for i in range(rows):
    for j in range(cols):
        ax = axes[i, j]
        ax.imshow(responses[i*cols +j ],cmap='gray')
        ax.axis('off')
```

```
(6, 6, 49, 49)
```


Combined Edge and Bar Filters (Y component)



```
count 36
```



In [ ]:

```
mr8_image = cv2.imread("Images/image-35.jpg")
b,g,r = cv2.split(mr8_image)
b_response = apply_rfs_filter_scipy(b, rfs_filters)
g_response = apply_rfs_filter_scipy(g, rfs_filters)
r_response = apply_rfs_filter_scipy(r, rfs_filters)
```

In [ ]:

```
combined_responses = []

# Combine the responses for each filter (total of 6 filters)
for i in range(6):  # Assuming each response set has shape (H, W, 6)
    # Stack the R, G, B responses into a single RGB image
    combined_rgb = cv2.merge((b_response[:, :, i], g_response[:, :, i], r_response[:, :, i]))
    combined_responses.append(combined_rgb)

fig, axes = plt.subplots(nrows = 2, ncols= 3, figsize=(16,8), sharex= True, sharey = True)
for i in range(1,7):
    plt.subplot(2,3,i)
    plt.imshow(combined_responses[i-1])
    plt.axis("off")
```

```
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers).
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Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers).
```
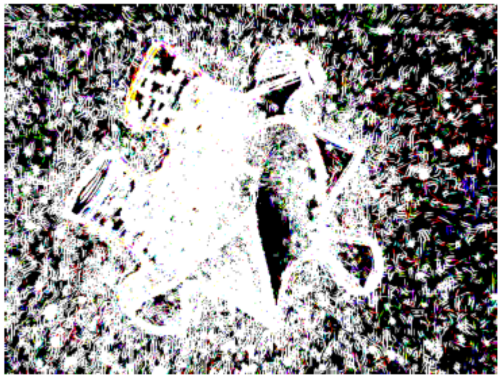






Question 3

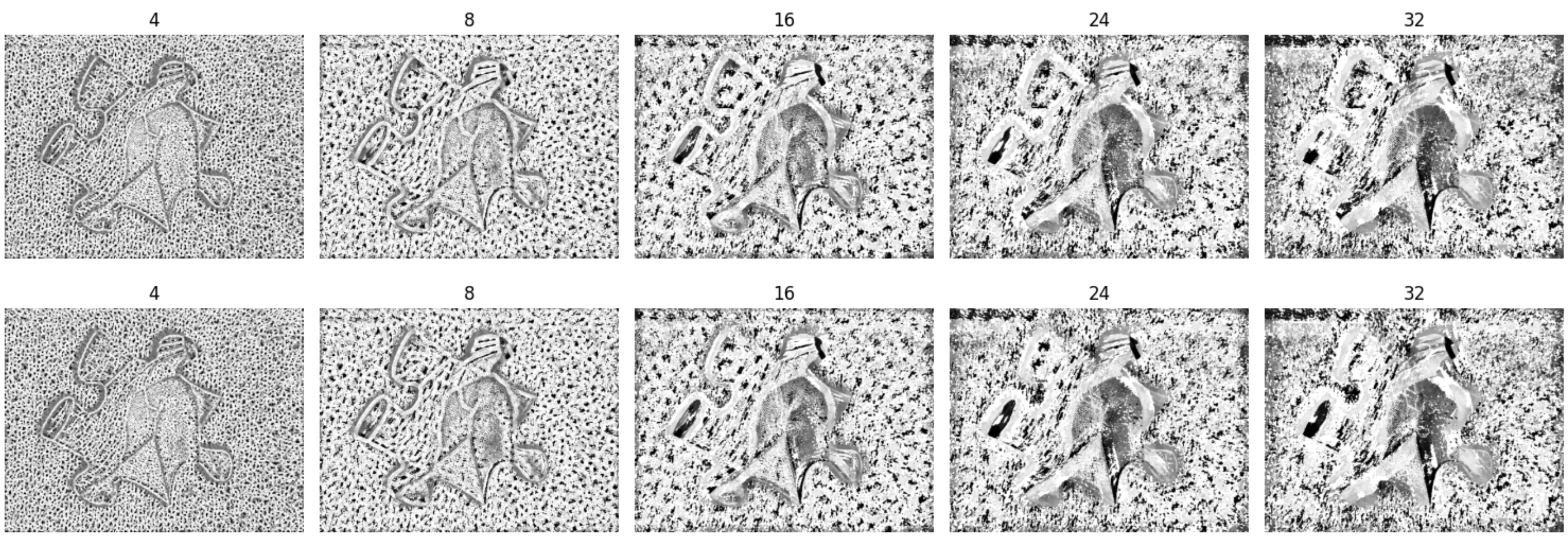
In [ ]:
```
def getLBPs(img,show_plot=False):
    lbps = []
    radii = [4, 8, 16, 24, 32]
    for radius in radii:
        lbp = skimage.feature.local_binary_pattern(img,12,radius,'uniform')
        lbps.append(lbp)

    if show_plot:
        fig, axes = plt.subplots(1, 5, figsize=(15, 5))
        for i, (img, label) in enumerate(zip(lbps, radii)):
            axes[i].imshow(img, cmap="gray")
            axes[i].axis('off')
            axes[i].set_title(label)

        plt.tight_layout()
        plt.show()

    return np.array(lbps)
```

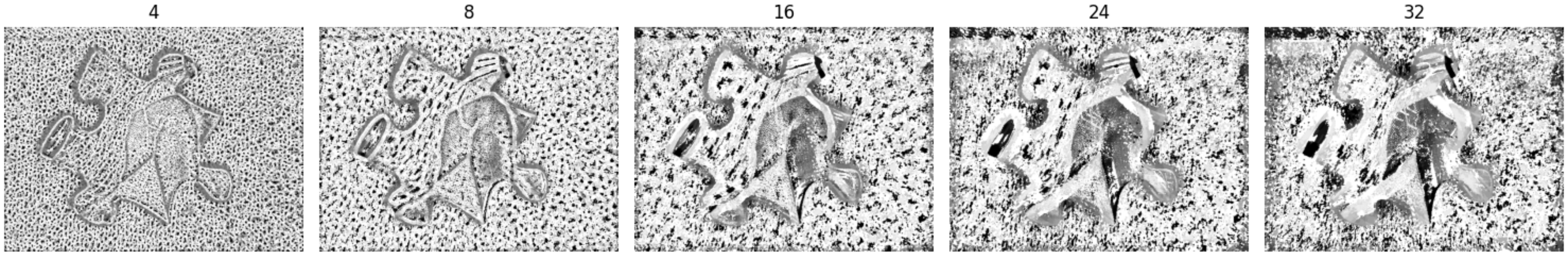
In [ ]:
```
def apply_haar_filter(integral_images, filter_size,show_plot=False):
    h, w = integral_images[0].shape
    # integral images have a buffer at the end of each axis
    h= h-1
    w= w-1
    response = np.zeros((len(integral_images),h,w))

    for i in range(len(integral_images)):  # For each channel (R, G, B)
        integral_image = integral_images[i]

        for y in range(h):
            for x in range(w):
                A = integral_image[max(0,y - filter_size//2),max(0,x - filter_size//2)]
                B = integral_image[max(0,y - filter_size//2),min(w,x + filter_size//2)]
                C = integral_image[min(h,y + filter_size//2),max(0,x - filter_size//2)]
                D = integral_image[min(h,y + filter_size//2), min(w,x + filter_size//2)]

                pos_sum = A + D

                neg_sum = B + C

                response[i,y,x] = pos_sum - neg_sum
```

```
    if show_plot:
        fig, axes = plt.subplots(1, 3, figsize=(15, 5))
        for i  in range(response.shape[0]):
            axes[i].imshow(response[i].astype(np.uint8), cmap = 'gray' )
            axes[i].axis('off')

        plt.tight_layout()
        plt.show()

    return response
```

In [ ]:

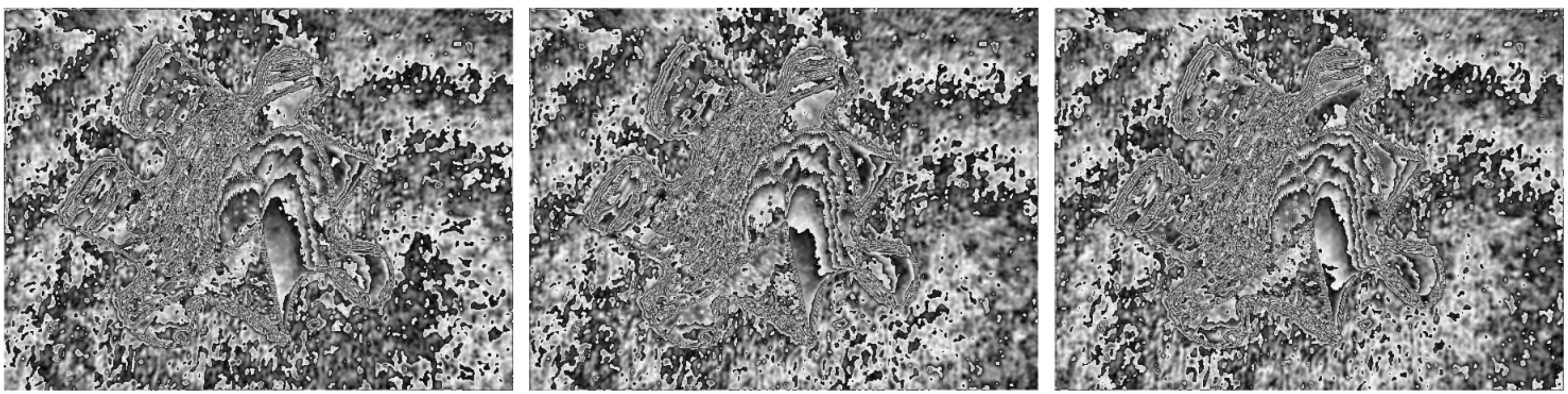
```
img = cv2.imread('Images/image-35.jpg')
red, green, blue = cv2.split(img)

red_lbps = getLBPs(red,show_plot=True)
green_lbps = getLBPs(green,show_plot=True)
blue_lbps = getLBPs(blue,show_plot=True)
print(red_lbps[0].shape)
print(green_lbps[0].shape)
print(blue_lbps[0].shape)
```

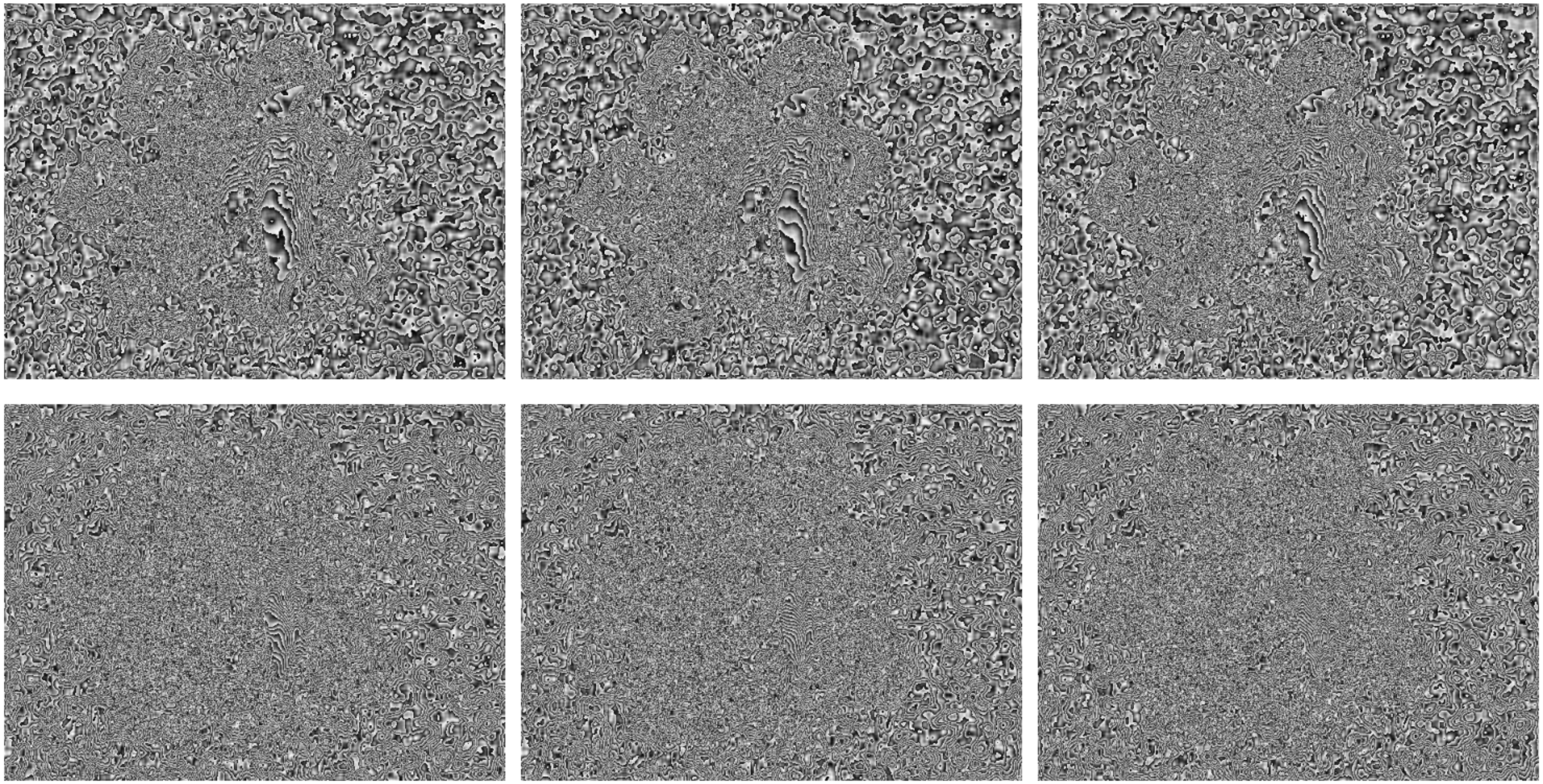





```
(450, 600)
(450, 600)
(450, 600)
```

In [ ]:
```
img = cv2.imread('Images/image-35.jpg')
integral_images =[cv2.integral(img[:, :, i]) for i in range(3)]

haar_response4 = apply_haar_filter(integral_images,4,True)
haar_response8 = apply_haar_filter(integral_images,8,True)
haar_response16 = apply_haar_filter(integral_images,16,True)
print(haar_response4.shape)
print(haar_response8.shape)
print(haar_response16.shape)
```





```
(3, 450, 600)
(3, 450, 600)
(3, 450, 600)
```

Section 4

In [ ]:
```
from scipy.stats import multivariate_normal
from sklearn.preprocessing import OneHotEncoder

class Stat_Classifier:

    def __init__(self,image) -> None:
        self.image = image
        self.kmeans = None
        pass
```

```
    def classify(self, validation_features, fg_features, bg_features, train_mask, train_image):
        # Compute the means and covariances for foreground and background
        fg_feature_matrix = np.stack(fg_features, axis=-1)
        fg_mean_vector = np.mean(fg_feature_matrix, axis=0)
        fg_cov_matrix = np.cov(fg_feature_matrix, rowvar=False)

        bg_feature_matrix = np.stack(bg_features, axis=-1)
        bg_mean_vector = np.mean(bg_feature_matrix, axis=0)
        bg_cov_matrix = np.cov(bg_feature_matrix, rowvar=False)

        print("Features extracted from original")

        # Reshape the validation features for pixel-wise processing
        reshaped_features = validation_features.T
        print("Reshaped the test features")


        probabilities = self.foreground_given_pixel(reshaped_features, fg_mean_vector, fg_cov_matrix,
                                                    bg_mean_vector, bg_cov_matrix,mask,image)
        print("Computed the feature array probabilities")
        return probabilities.reshape((450,600))



    def foreground_given_pixel(self,x,fg_mean, fg_cov, bg_mean, bg_cov,mask,image):
        """
        Args:
            mask (2d array): Remember to binarize it.
            image (type):the original image.

        Returns:
            type: probability.
        """
        N = image.shape[0]*image.shape[1]
        N_fg = np.sum(mask)
        N_bg = N - N_fg

        numerator = multivariate_normal.pdf( x, mean = fg_mean, cov= fg_cov, allow_singular=True) * (N_fg)
        denominator = multivariate_normal.pdf(x, mean=fg_mean, cov=fg_cov, allow_singular=True)*N_fg \
                    + multivariate_normal.pdf( x, mean= bg_mean, cov= bg_cov, allow_singular=True) * (N_bg)
        small_value = 1e-10  # You can adjust the small value if needed
        denominator = np.where(denominator == 0, small_value, denominator)
```

```
        probability = numerator/denominator
        return probability

    def getFeatures(self,training_img, mask, show_plot=False,MR8:bool = False, texton:bool = False, desired_sigma = 1
        """
        Parameters:
            training_img (2d array): training image.
            mask (type): binarized image.

        Returns:
            type: Flattened features.
        """
        if(type(mask[0][0]) != np.bool_):
            binary_mask = mask >128

        vertical_prewitt = np.array([
            [1,1,1],
            [0,0,0],
            [-1,-1,-1]
        ])
        horizontal_prewitt = np.array([
            [1,0,-1],
            [1,0,-1],
            [1,0,-1]
        ])

        laplacian = np.array([
            [0,-1,0],
            [-1,4,-1],
            [0,-1,0]
        ])
        # ceil(6*sigma) x ceil(6*sigma)

        kernel_size = np.ceil(6*desired_sigma)**2
        gauss = GaussFilter(kernel_size, desired_sigma)
        lgauss =  LoG(kernel_size, desired_sigma)
        dgauss = DoG(kernel_size,desired_sigma,2)

        binary_mask = mask>128
        #plt.imshow(binary_mask)

        #add dimensions
```

```
    # print(binary_mask.shape)
    hsv_training_img = cv2.cvtColor(training_img, cv2.COLOR_BGR2RGB)
    v,s,h = cv2.split(hsv_training_img)
    h, s,v = h*binary_mask, s*binary_mask, v*binary_mask
    # print(h.shape)
    b,g,r = cv2.split(training_img)
    r,g,b = r*binary_mask, g*binary_mask, b*binary_mask


    # get vertical prewitt for separated channels

    vert_prewitt_r = cv2.filter2D(src=r, ddepth=-1, kernel=vertical_prewitt)
    vert_prewitt_g = cv2.filter2D(src=g, ddepth=-1, kernel=vertical_prewitt)
    vert_prewitt_b = cv2.filter2D(src=b, ddepth=-1, kernel=vertical_prewitt)
    # get horizontal prewitt for separated channels

    hori_prewitt_r = cv2.filter2D(src=r, ddepth=-1, kernel=horizontal_prewitt)
    hori_prewitt_g = cv2.filter2D(src=g, ddepth=-1, kernel=horizontal_prewitt)
    hori_prewitt_b = cv2.filter2D(src=b, ddepth=-1, kernel=horizontal_prewitt)
    # get Laplacian for separated channels

    laplace_r = cv2.filter2D(src=r, ddepth=-1, kernel=laplacian)
    laplace_g = cv2.filter2D(src=g, ddepth=-1, kernel=laplacian)
    laplace_b = cv2.filter2D(src=b, ddepth=-1, kernel=laplacian)

    # get gaussian for seperate channels
    gauss_r = cv2.filter2D(src=r, ddepth=-1, kernel = gauss)
    gauss_g = cv2.filter2D(src=g, ddepth=-1, kernel = gauss)
    gauss_b = cv2.filter2D(src=b, ddepth=-1, kernel = gauss)

    # get log of gaussian for seperate channels
    l_gauss_r = cv2.filter2D(src=r, ddepth=-1, kernel = lgauss)
    l_gauss_g = cv2.filter2D(src=g, ddepth=-1, kernel = lgauss)
    l_gauss_b = cv2.filter2D(src=b, ddepth=-1, kernel = lgauss)

    # get log of gaussian for seperate channels
    d_gauss_r = cv2.filter2D(src=r, ddepth=-1, kernel = dgauss)
    d_gauss_g = cv2.filter2D(src=g, ddepth=-1, kernel = dgauss)
    d_gauss_b = cv2.filter2D(src=b, ddepth=-1, kernel = dgauss)

    # get LBPs for seperate channels
    lbp_r = getLBPs(r)
```

```
lbp_g = getLBPs(g)
lbp_b = getLBPs(b)

# get Harr for seperate channels and sizes
integral_images = [cv2.integral(training_img[:,:,i]) for i in range(3)]
haar4 = apply_haar_filter(integral_images,4)
haar8 = apply_haar_filter(integral_images,8)
haar16 = apply_haar_filter(integral_images,16)

if show_plot:
    # vertical prewitt plot
    fig, axes = plt.subplots(nrows = 1, ncols = 3, figsize=(16,4))
    plt.subplot(1,3,1), plt.imshow( vert_prewitt_r,cmap="gray"), plt.axis("off")
    plt.subplot(1,3,2), plt.imshow( vert_prewitt_g,cmap="gray"), plt.axis("off")
    plt.subplot(1,3,3), plt.imshow( vert_prewitt_b,cmap="gray"), plt.axis("off")
    plt.suptitle("Vertical Prewitt of RGB image")
    plt.show()

    # horizontal prewitt plot
    fig, axes = plt.subplots(nrows = 1, ncols = 3, figsize=(16,4))
    plt.subplot(1,3,1), plt.imshow( hori_prewitt_r,cmap="gray"), plt.axis("off")
    plt.subplot(1,3,2), plt.imshow( hori_prewitt_g,cmap="gray"), plt.axis("off")
    plt.subplot(1,3,3), plt.imshow( hori_prewitt_b,cmap="gray"), plt.axis("off")
    plt.suptitle("Horizontal Prewitt of RGB image")
    plt.show()

    # laplace plot
    fig, axes = plt.subplots(nrows = 1, ncols = 3, figsize=(16,4))
    plt.subplot(1,3,1), plt.imshow( laplace_r,cmap="gray"), plt.axis("off")
    plt.subplot(1,3,2), plt.imshow( laplace_g,cmap="gray"), plt.axis("off")
    plt.subplot(1,3,3), plt.imshow( laplace_b,cmap="gray"), plt.axis("off")
    plt.suptitle("Laplacian of RGB image")
    plt.show()

    # gaussian plot
    fig, axes = plt.subplots(nrows = 1, ncols = 3, figsize=(16,4))
    plt.subplot(1,3,1), plt.imshow( gauss_r,cmap="gray"), plt.axis("off")
    plt.subplot(1,3,2), plt.imshow( gauss_g,cmap="gray"), plt.axis("off")
    plt.subplot(1,3,3), plt.imshow( gauss_b,cmap="gray"), plt.axis("off")
    plt.suptitle("Gaussian of RGB image")
    plt.show()
```

```python
# log of gaussian plot
fig, axes = plt.subplots(nrows = 1, ncols = 3, figsize=(16,4))
plt.subplot(1,3,1), plt.imshow( l_gauss_r,cmap="gray"), plt.axis("off")
plt.subplot(1,3,2), plt.imshow( l_gauss_g,cmap="gray"), plt.axis("off")
plt.subplot(1,3,3), plt.imshow( l_gauss_b,cmap="gray"), plt.axis("off")
plt.suptitle("Log of Gaussian of RGB image")
plt.show()

# difference of gaussian plot
fig, axes = plt.subplots(nrows = 1, ncols = 3, figsize=(16,4))
plt.subplot(1,3,1), plt.imshow( d_gauss_r,cmap="gray"), plt.axis("off")
plt.subplot(1,3,2), plt.imshow( d_gauss_g,cmap="gray"), plt.axis("off")
plt.subplot(1,3,3), plt.imshow( d_gauss_b,cmap="gray"), plt.axis("off")
plt.suptitle("Difference of Gaussian of RGB image")
plt.show()

# LBP Red plot
fig, axes = plt.subplots(1, 5, figsize=(15, 5))
for i, (img, label) in enumerate(zip(lbp_r, [4,8,16,24,32])):
    axes[i].imshow(img, cmap="gray")
    axes[i].axis('off')
    axes[i].set_title(label)

plt.suptitle("LBPs of Red image")
plt.show()

# LBP Green plot
fig, axes = plt.subplots(1, 5, figsize=(15, 5))
for i, (img, label) in enumerate(zip(lbp_g, [4,8,16,24,32])):
    axes[i].imshow(img, cmap="gray")
    axes[i].axis('off')
    axes[i].set_title(label)

plt.suptitle("LBPs of Green image")
plt.show()

# LBP Blue plot
fig, axes = plt.subplots(1, 5, figsize=(15, 5))
for i, (img, label) in enumerate(zip(lbp_b, [4,8,16,24,32])):
    axes[i].imshow(img, cmap="gray")
    axes[i].axis('off')
```

```
            axes[i].set_title(label)

        plt.suptitle("LBPs of Blue image")
        plt.show()

        # Haar4 Filter plot
        fig, axes = plt.subplots(1, 3, figsize=(15, 5))
        for i  in range(haar4.shape[0]):
            axes[i].imshow(haar4[i].astype(np.uint8),cmap="gray")
            axes[i].axis('off')

        plt.suptitle("Haar 4 of RGB image")
        plt.show()

        # Haar8 Filter plot
        fig, axes = plt.subplots(1, 3, figsize=(15, 5))
        for i  in range(haar8.shape[0]):
            axes[i].imshow(haar8[i].astype(np.uint8),cmap="gray")
            axes[i].axis('off')

        plt.suptitle("Haar 8 of RGB image")
        plt.show()

        # Haar16 Filter plot
        fig, axes = plt.subplots(1, 3, figsize=(15, 5))
        for i  in range(haar16.shape[0]):
            axes[i].imshow(haar16[i].astype(np.uint8),cmap="gray")
            axes[i].axis('off')

        plt.suptitle("Haar 16 of RGB image")
        plt.show()


    features = []
    if (feature_matrix[0]):
        features.extend([ vert_prewitt_r, hori_prewitt_r,
            vert_prewitt_g, hori_prewitt_g,
            vert_prewitt_b, hori_prewitt_b,
            laplace_r, laplace_g, laplace_b,])
    if (feature_matrix[1]):
        features.extend([gauss_r, l_gauss_r, d_gauss_r,
            gauss_g, l_gauss_g, d_gauss_g,
```

```
                gauss_b, l_gauss_b, d_gauss_b,])
        if (feature_matrix[2]):
            features.extend([lbp_r[0],lbp_r[1],lbp_r[2],lbp_r[3],lbp_r[4],
                lbp_g[0],lbp_g[1],lbp_g[2],lbp_g[3],lbp_g[4],
                lbp_b[0],lbp_b[1],lbp_b[2],lbp_b[3],lbp_b[4],])
        if (feature_matrix[3]):
            features.extend([haar4[0],haar4[1],haar4[1],
                haar8[0],haar8[1],haar8[1],
                haar16[0],haar16[1],haar16[1],])
        if (feature_matrix[4]):
            features.extend([r, g, b,])
        if (feature_matrix[5]):
            features.extend([ h, s, v,])


        flattened_features = np.array([f[binary_mask].flatten() for f in features])
        print("Shape of flattened_features before texton:", flattened_features.shape)
        if texton:

            textons = self.textons(image, mask)

            # One-hot encode the textons
            encoder = OneHotEncoder(categories=[range(4)], sparse_output=False)
            textons_one_hot = encoder.fit_transform(textons.flatten().reshape(-1, 1))


            # Transpose filtered_textons to get the shape
            filtered_textons = textons_one_hot.T

            print("Shape of filtered_textons:", filtered_textons.shape)

            # Concatenate along the features axis (features should be appended)
            concatenated_features = np.concatenate([flattened_features, filtered_textons], axis=0)

            print("Shape of concatenated_features:", concatenated_features.shape)



        return np.array(flattened_features)

    def textons(self, image, mask, plot=False):
        original_features = self.getFeatures(image, mask, False)
```

```
        print(original_features.shape)

        perpixel_features = np.swapaxes(original_features, 0, 1)
        print("Clustering!")

        # mask_flattened = mask.flatten()
        # masked_features = perpixel_features[mask_flattened]

        kmeans = KMeans(n_clusters=4, random_state=42).fit(perpixel_features)
        textons_intern = kmeans.labels_


        if plot:
            plt.imshow(textons_intern.reshape(mask.shape))
            plt.show()

        return textons_intern

    def dummy_test(self, image_path):
        # Mask,inverse and image (original in the lab1)

        # Example usage within the dummy_test or other testing functions:
        image = cv2.imread("Images/image-35.jpg")
        mask = cv2.imread("Images/mask-35.png", cv2.IMREAD_GRAYSCALE)
        inverse_mask = 255 - mask
        class_inst = Stat_Classifier(image)

        # Extract textons from the training image
        # train_textons = class_inst.textons(image, )

        # Validation features
        null = np.ones_like(mask) * 255
        validation_img = cv2.imread("Images/image-83.jpg")

        validation_features = class_inst.getFeatures(validation_img, null, show_plot=False, texton=True)
        fg_features = class_inst.getFeatures(image, mask, show_plot=False, texton=True)
        bg_features = class_inst.getFeatures(image, inverse_mask, show_plot=False, texton=True)

        # Extract textons for the validation image
        # validation_textons = class_inst.textons(validation_img, null)

        # Classify
```

```
        verify_img = class_inst.classify(validation_features, fg_features, bg_features, mask, image)
        theta = 0.5
        thresholded_img = verify_img.copy() > theta
        plt.figure()
        plt.imshow(thresholded_img, cmap="gray"), plt.title("Validation image prediction")
        plt.show()
        return verify_img

        # accuracy
```

4.2 Find and display Textons

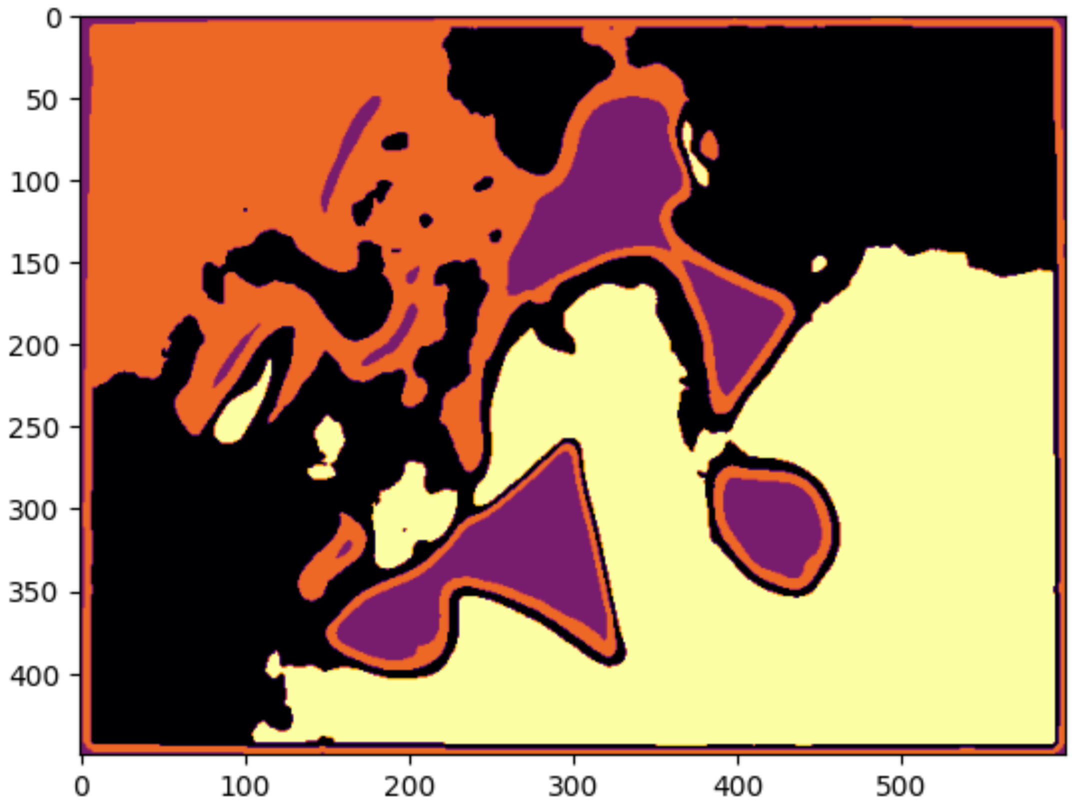
In [ ]:

```
image = cv2.imread("Images/image-35.jpg")
mask = cv2.imread("Images/mask-35.png", cv2.IMREAD_GRAYSCALE)
classify_inst = Stat_Classifier(image)
null = np.ones_like(mask)*255
original_features = classify_inst.getFeatures(image,null,False)
print(original_features.shape)

perpixel_features = np.swapaxes(original_features,0,1)

kmeans = KMeans(n_clusters=4, random_state=42).fit(perpixel_features)
textons = kmeans.labels_
plt.imshow(textons.reshape(450,600), cmap="inferno")
```

```
Shape of flattened_features before texton: (48, 270000)
(48, 270000)
```

Out[ ]:

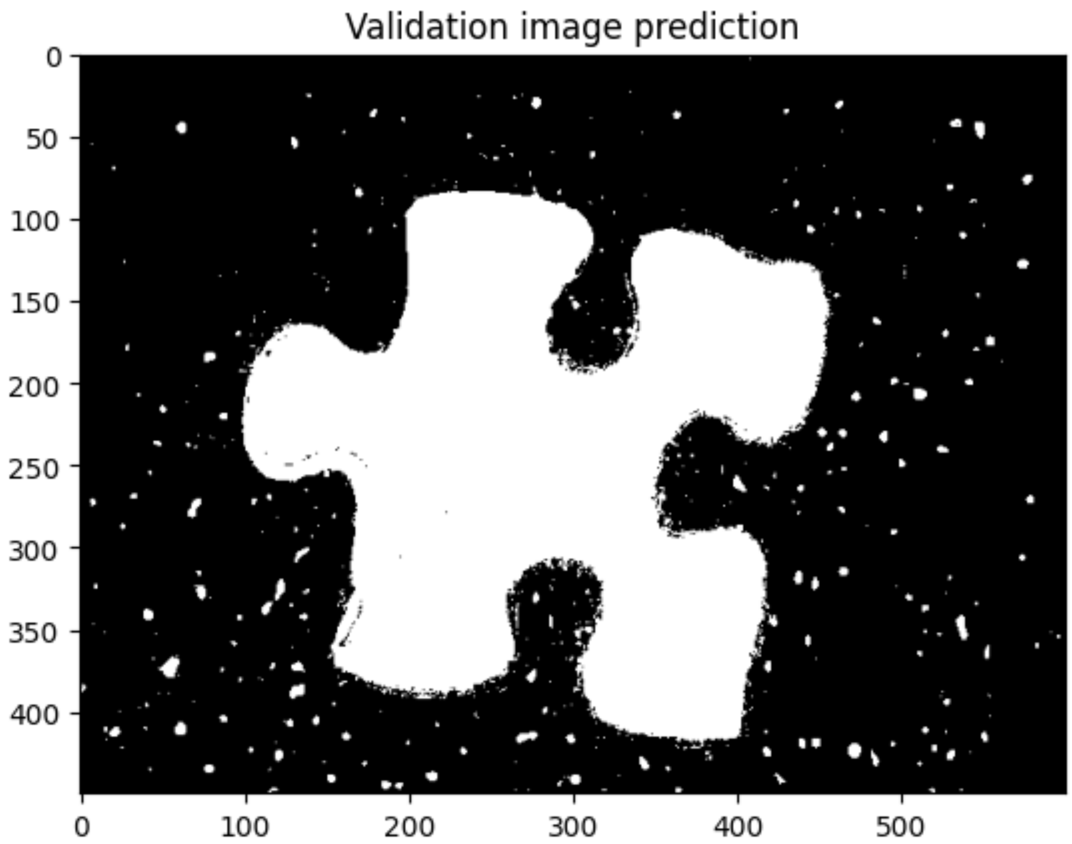
```
<matplotlib.image.AxesImage at 0x20c04ab49b0>
```



4.3 Testing model accuracy on test Image

In [ ]:
```
test_image = cv2.imread("Images/image-83.jpg")
image = cv2.imread("Images/image-35.jpg")
print(test_image.shape)
mask = cv2.imread("Images/mask-35.png", cv2.IMREAD_GRAYSCALE)
null = np.ones_like(mask)*255

classify_inst = Stat_Classifier(image)

print("classifying the test image")
test_img_result = classify_inst.dummy_test("Images/image-83.jpg")
```

```
(450, 600, 3)
classifying the test image
Shape of flattened_features before texton: (48, 270000)
Shape of flattened_features before texton: (48, 270000)
(48, 270000)
Clustering!
Shape of filtered_textons: (4, 270000)
Shape of concatenated_features: (52, 270000)
Shape of flattened_features before texton: (48, 74571)
Shape of flattened_features before texton: (48, 74571)
(48, 74571)
Clustering!
Shape of filtered_textons: (4, 74571)
Shape of concatenated_features: (52, 74571)
Shape of flattened_features before texton: (48, 195424)
Shape of flattened_features before texton: (48, 195424)
(48, 195424)
Clustering!
Shape of filtered_textons: (4, 195424)
Shape of concatenated_features: (52, 195424)
Features extracted from original
Reshaped the test features
Computed the feature array probabilities
```



Accuracy using textons - IOU SCORE

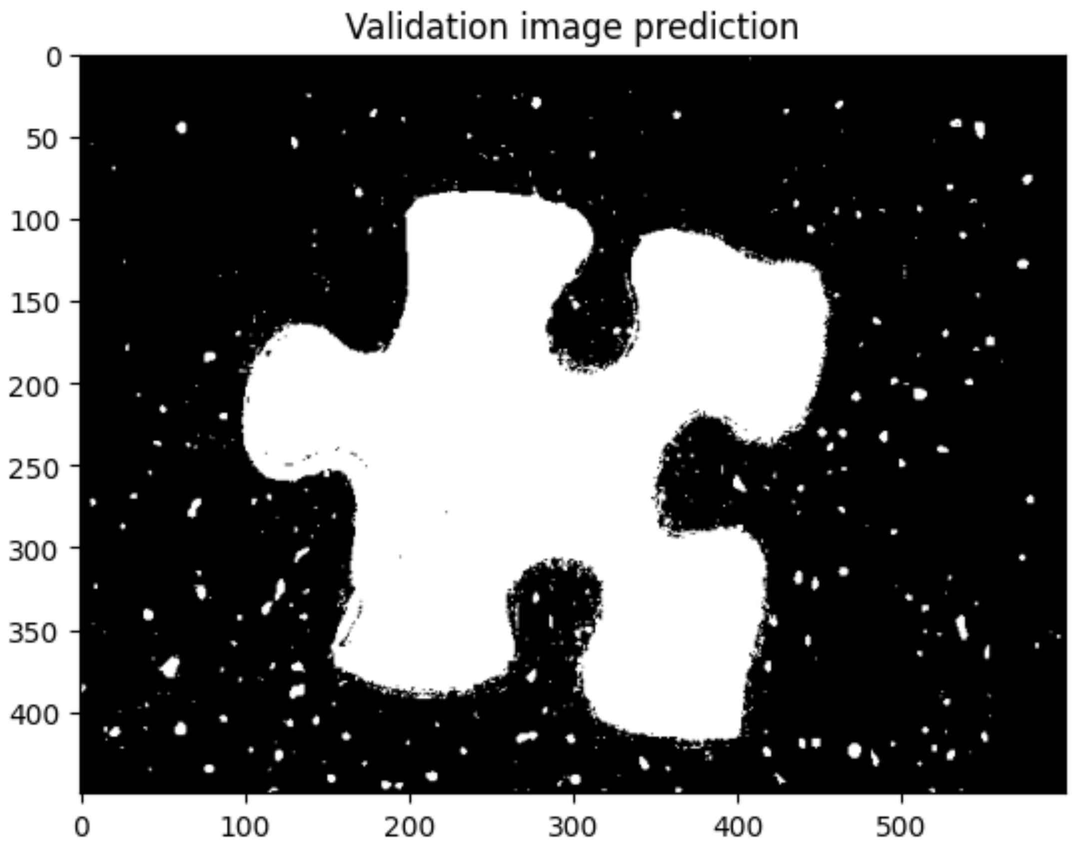
In [ ]:
```
from sklearn.metrics import confusion_matrix
test_mask = cv2.imread("Images/mask-83.png", cv2.IMREAD_GRAYSCALE)
def get_IOU_PosNeg(img1,img2):
    conf_matrix = confusion_matrix((img1 >0.99).astype(int).flatten(), (img2 >0.99).astype(int).flatten())
    TN = conf_matrix[0][0]
    fn = conf_matrix[1][0]
    tp = conf_matrix[1][1]
    fp = conf_matrix[0][1]
    iou = tp / (tp + fp + fn)

    return iou
print(get_IOU_PosNeg(test_mask, test_img_result))
```

```
0.8281889785202214
```

4.4 Using MR8 for classifier

In [ ]:
```
image = cv2.imread("Images/image-35.jpg")
mask = cv2.imread("Images/mask-35.png", cv2.IMREAD_GRAYSCALE)
inverse_mask = 255 - mask
class_inst = Stat_Classifier(image)


# Validation features
null = np.ones_like(mask) * 255
validation_img = cv2.imread("Images/image-83.jpg")

validation_features = class_inst.getFeatures(validation_img, null, show_plot=False,MR8= True, texton=True)
fg_features = class_inst.getFeatures(image, mask, show_plot=False,MR8= True, texton=True)
bg_features = class_inst.getFeatures(image, inverse_mask, show_plot=False,MR8= True, texton=True)



# Classify
verify_img = class_inst.classify(validation_features, fg_features, bg_features, mask, image)
theta = 0.5
thresholded_img = verify_img.copy() > theta
plt.figure()
plt.imshow(thresholded_img, cmap="gray"), plt.title("Validation image prediction")
plt.show()
```

```
Shape of flattened_features before texton: (48, 270000)
Shape of flattened_features before texton: (48, 270000)
(48, 270000)
Clustering!
Shape of filtered_textons: (4, 270000)
Shape of concatenated_features: (52, 270000)
Shape of flattened_features before texton: (48, 74571)
Shape of flattened_features before texton: (48, 74571)
(48, 74571)
Clustering!
Shape of filtered_textons: (4, 74571)
Shape of concatenated_features: (52, 74571)
Shape of flattened_features before texton: (48, 195424)
Shape of flattened_features before texton: (48, 195424)
(48, 195424)
Clustering!
Shape of filtered_textons: (4, 195424)
Shape of concatenated_features: (52, 195424)
Features extracted from original
Reshaped the test features
Computed the feature array probabilities
```



Accuracy of MR8 + TExtons - IOU SCORE

In [ ]:
```
test_mask = cv2.imread("Images/mask-83.png", cv2.IMREAD_GRAYSCALE)
print(get_IOU_PosNeg(test_mask, verify_img))
```

```
0.8281889785202214
```

Question 4.5

In [ ]:
```
import sklearn.linear_model


image = cv2.imread("Images/image-35.jpg")
mask = cv2.imread("Images/mask-35.png", cv2.IMREAD_GRAYSCALE)
mask = mask>=127.5
```

```
null = np.ones_like(mask)*255

classify_inst = Stat_Classifier(image)

original_features = classify_inst.getFeatures(image,null,False,MR8=True)

perpixel_features = np.swapaxes(original_features,0,1)

log_reg = sklearn.linear_model.LogisticRegression().fit(perpixel_features,mask.flatten())
```

```
Shape of flattened_features before texton: (48, 270000)
```

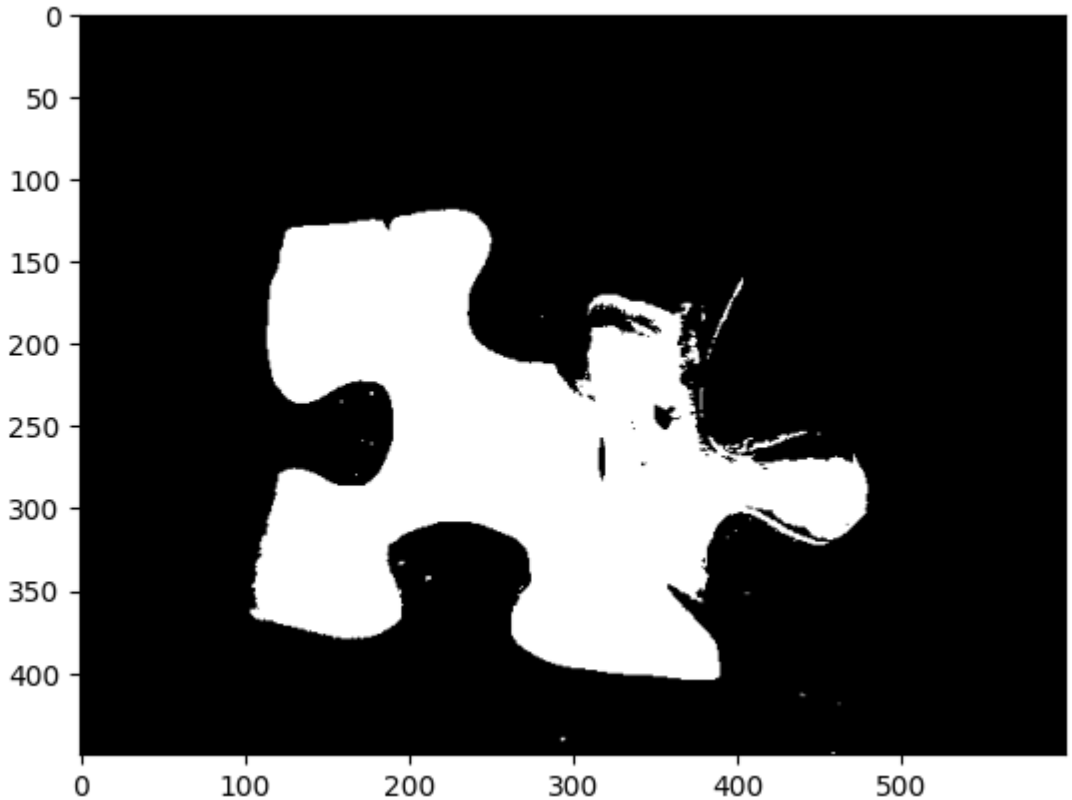
```
c:\Users\Tumi\AppData\Local\Programs\Python\Python312\Lib\site-packages\sklearn\linear_model\_logistic.py:469: Conver
genceWarning: lbfgs failed to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression
  n_iter_i = _check_optimize_result(
```

In [ ]:

```
ver = cv2.imread("Images/image-110.jpg")
mask = cv2.imread("Images/mask-110.png", cv2.IMREAD_GRAYSCALE)
mask = mask>=127.5
ver_features = classify_inst.getFeatures(ver,null,False,MR8=True,texton=True)
ver_perpixel_features = np.swapaxes(ver_features,0,1)

predictions = log_reg.predict(ver_perpixel_features)
print("Accuracy", log_reg.score(ver_perpixel_features,mask.flatten()))

print(predictions.shape)

plt.imshow(predictions.reshape(450,600),cmap = 'gray')
```

```
Shape of flattened_features before texton: (48, 270000)
Shape of flattened_features before texton: (48, 270000)
(48, 270000)
Clustering!
Shape of filtered_textons: (4, 270000)
Shape of concatenated_features: (52, 270000)
Accuracy 0.9646851851851852
(270000,)
```

Out[ ]: <matplotlib.image.AxesImage at 0x20c05924a40>



In [ ]: