INSTITUTO FEDERAL DE EDUCAÇÃO, CIÊNCIA E TECNOLOGIA SÃO PAULO Campus Birigui	**INSTITUTO FEDERAL DE EDUCAÇÃO, CIÊNCIA E TECNOLOGIA** **Campus Birigui** **Bacharelado em Engenharia de Computação**
Disciplina: Processamento Digital de Imagem	Relatório – Filtragem Espacial
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Filtragem

Espacial

Birigui 2023

FiltragemEspacial

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1 Filtragem Espacial

1.1 A. Implementar a operação de convolução utilizando OPENCV, scipy função convolve e implementação manual.

1.2 B. Implementar seguintes máscaras:

- Média
- Gaussiano
- Laplaciano
- Sobel X
- Sobel Y
- Gradiente (Sobel X + Sobel Y)
- Laplaciano somado a imagem original

1.3 Importando bibliotecas

[24]:

```
import numpy as np
from numpy import asarray
from PIL import Image, ImageFilter
import cv2
from scipy.signal import convolve2d, medfilt
import matplotlib.pyplot as plt
from matplotlib import pyplot as plt
```

1.4 Máscaras de convolução

1.4.1 masks(title) :: void

função responsável por aplicar as máscaras de convolução na imagem original de acordo com o título passado como parâmetro.

[25]:

```
def masks(title):
    if title.lower() == 'identidade':
        return np.array((
        [0, 0, 0],
        [0, 1, 0],
        [0, 0, 0]), dtype="int")
    elif title.lower() == 'média':
        return np.array((
        [0.1111, 0.1111, 0.1111],
        [0.1111, 0.1111, 0.1111],
        [0.1111, 0.1111, 0.1111]), dtype="float")
    elif title.lower() == 'gauss':
        return np.array((
        [0.0625, 0.125, 0.0625],
        [0.1250, 0.250, 0.1250],
        [0.0625, 0.125, 0.0625]), dtype="float")
    elif title.lower() == 'laplaciano':
        return np.array((
        [0,  1, 0],
        [1, -4, 1],
        [0,  1, 0]), dtype="int")
    elif title.lower() == 'sobelx':
        return np.array((
        [-1, -2, -1],
        [ 0,  0,  0],
        [ 1,  2,  1]), dtype="int")
    elif title.lower() == 'sobely':
        return np.array((
        [-1, 0, 1],
        [-2, 0, 2],
        [-1, 0, 1]), dtype="int")
    elif title.lower() == 'prewittx':
        return np.array((
        [-1, -1, -1],
        [ 0,  0,  0],
        [ 1,  1,  1]), dtype="int")
    elif title.lower() == 'prewitty':
        return np.array((
        [-1, 0, 1],
        [-1, 0, 1],
        [-1, 0, 1]), dtype="int")
    elif title.lower() == 'robertsx':
        return np.array((
        [0, 0, 0],
        [0, 0, 1],
        [0,-1, 0]), dtype="int")
    elif title.lower() == 'robertsy':
        return np.array((
        [0, 0, 0],
        [0, 1, 0],
        [0, 0,-1]), dtype="int")
    elif title.lower() == 'boost':
        return np.array((
        [ 0,  -1,  0],
        [-1, 5.7, -1],
        [ 0,  -1,  0]), dtype="float")
    else:
        return np.array((
        [0, 0, 0],
        [0, 1, 0],
        [0, 0, 0]), dtype="int")
```

1.4.2 print_final_result() :: void

função responsável por mostrar o resultado final da imagem através da biblioteca matplotlib e aplicar as transformações geométricas na imagem original.

[26]:
```
def print_final_result(img_path1, img_path2, img_path3, mask_title,␣
 ↪function,lib, kernel_size = 3):
    if lib.lower() == 'opencv':
        imgBiel = cv2.imread(img_path1, cv2.IMREAD_GRAYSCALE)
        imgLena = cv2.imread(img_path2, cv2.IMREAD_GRAYSCALE)
        imgCameraman = cv2.imread(img_path3, cv2.IMREAD_GRAYSCALE)
    else:
        imgBiel = Image.open(img_path1)
        f_imgBiel = asarray(imgBiel)
        imgLena = Image.open(img_path2)
        f_imgLena = asarray(imgLena)
        imgCameraman = Image.open(img_path3)
        f_imgCameraman = asarray(imgCameraman)

    plt.subplots_adjust(wspace=0.2, hspace=0.01)

    plt.figure(figsize=(24, 12))
    plt4 = plt.subplot(2,3,1)
    plt5 = plt.subplot(2,3,2)
    plt6 = plt.subplot(2,3,3)
    plt1 = plt.subplot(2,3,4)
    plt2 = plt.subplot(2,3,5)
    plt3 = plt.subplot(2,3,6)

    plt4.set_title('Original Biel')
    plt5.set_title('Original Lena')
    plt6.set_title('Original Cameraman')

    mascara = masks(mask_title)
    if mascara != 'Máscara não encontrada':
        if (lib.lower() == 'opencv'):
            plt1.imshow(function(imgBiel, mascara), cmap='gray', vmin=0,␣
 ↪vmax=255)
```

```
            plt2.imshow(function(imgLena, mascara), cmap='gray', vmin=0,␣
↪vmax=255)
            plt3.imshow(function(imgCameraman, mascara), cmap='gray', vmin=0,␣
↪vmax=255)
            plt4.imshow(imgBiel, cmap='gray', vmin=0, vmax=255)
            plt5.imshow(imgLena, cmap='gray', vmin=0, vmax=255)
            plt6.imshow(imgCameraman, cmap='gray', vmin=0, vmax=255)

        elif (lib.lower() == 'scipy'):
            plt1.imshow(function(f_imgBiel, mascara), cmap='gray', vmin=0,␣
↪vmax=255)
            plt2.imshow(function(f_imgLena, mascara), cmap='gray', vmin=0,␣
↪vmax=255)
            plt3.imshow(function(f_imgCameraman, mascara), cmap='gray', vmin=0,␣
↪vmax=255)
            plt4.imshow(imgBiel, cmap='gray', vmin=0, vmax=255)
            plt5.imshow(imgLena, cmap='gray', vmin=0, vmax=255)
            plt6.imshow(imgCameraman, cmap='gray', vmin=0, vmax=255)

        elif (lib.lower() == 'manual'):
            plt1.imshow(function(f_imgBiel, mascara), cmap='gray', vmin=0,␣
↪vmax=255)
            plt2.imshow(function(f_imgLena, mascara), cmap='gray', vmin=0,␣
↪vmax=255)
            plt3.imshow(function(f_imgCameraman, mascara), cmap='gray', vmin=0,␣
↪vmax=255)
            plt4.imshow(imgBiel, cmap='gray', vmin=0, vmax=255)
            plt5.imshow(imgLena, cmap='gray', vmin=0, vmax=255)
            plt6.imshow(imgCameraman, cmap='gray', vmin=0, vmax=255)
        else:
            print('Biblioteca não encontrada')
    else:
        print('Máscara não encontrada')
    print(mask_title.upper())
    plt.show()

    print()
```

1.5 A. Convolução utilizando OPENCV:

[27]:

```
#convolution using opencv
def convolution_opencv(img, kernel):
    return cv2.filter2D(img, -1, kernel)
```

1.6 A. Convolução utilizando Scipy:

[28]:

```
#convolution using scipy
def convolution_scipy(img, kernel):
    img = np.array(img)
    kernel = np.array(kernel)
    return convolve2d(img, kernel, mode='same', boundary='fill', fillvalue=0)
```

2 A. Convolução utilizando implementação manual:

[29]:

```
def convolution_manual(img, kernel):
    # Obter as dimensões da imagem e do kernel
    altura_imagem, largura_imagem = img.shape
    altura_kernel, largura_kernel = kernel.shape

    # Calcular o tamanho da imagem resultante
    altura_resultante = altura_imagem - altura_kernel + 1
    largura_resultante = largura_imagem - largura_kernel + 1

    # Inicializar a matriz da imagem resultante
    imagem_resultante = np.zeros((altura_resultante, largura_resultante))

    # Realizar a convolução manualmente
    for i in range(altura_resultante):
        for j in range(largura_resultante):
            janela = img[i:i+altura_kernel, j:j+largura_kernel]
            convolucao = np.sum(janela * kernel)
            imagem_resultante[i, j] = convolucao

    return imagem_resultante
```

2.1 B. Implementar seguintes máscaras utilizando a operação de convolução utilizando, separadamente, OpenCV, Scipy e implementação manual:

- Média
- Gaussiano
- Laplaciano
- Sobel X
- Sobel Y
- Gradiente (Sobel X + Sobel Y)
- Laplaciano somado a imagem original

2.1.1 gradiente_opencv() :: void

função responsável por aplicar o filtro de gradiente (Sobel X + Sobel Y) na imagem original utilizando a biblioteca OPENCV.

2.1.2 gradiente_scipy() :: void

função responsável por aplicar o filtro de gradiente (Sobel X + Sobel Y) na imagem original utilizando a biblioteca Scipy.

2.1.3 gradiente_manual() :: void

função responsável por aplicar o filtro de gradiente (Sobel X + Sobel Y) na imagem original utilizando a implementação manual.

[30]:

```
def gradiente_opencv(img):
    imgBiel = cv2.imread(img[0], cv2.IMREAD_GRAYSCALE)
    imgLena = cv2.imread(img[1], cv2.IMREAD_GRAYSCALE)
    imgCameraman = cv2.imread(img[2], cv2.IMREAD_GRAYSCALE)
    kernelx = masks('sobelx')
    kernely = masks('sobely')
    imgxBiel = convolution_opencv(imgBiel, kernelx)
    imgyBiel = convolution_opencv(imgBiel, kernely)
    imgxLena = convolution_opencv(imgLena, kernelx)
    imgyLena = convolution_opencv(imgLena, kernely)
    imgxCameraman = convolution_opencv(imgCameraman, kernelx)
    imgyCameraman = convolution_opencv(imgCameraman, kernely)
    plt.subplots_adjust(wspace=0.2, hspace=0.01)

    plt.figure(figsize=(24, 12))
    plt1 = plt.subplot(2,3,1)
    plt2 = plt.subplot(2,3,2)
    plt3 = plt.subplot(2,3,3)
    plt4 = plt.subplot(2,3,4)
    plt5 = plt.subplot(2,3,5)
    plt6 = plt.subplot(2,3,6)

    plt3.set_title('Biel')
    plt1.set_title('Lena')
    plt2.set_title('Cameraman')
    print('Gradiente: sobelx + sobely')
    plt1.imshow(imgBiel, cmap='gray', vmin=0, vmax=255)
    plt2.imshow(imgLena, cmap='gray', vmin=0, vmax=255)
    plt3.imshow(imgCameraman, cmap='gray', vmin=0, vmax=255)
    plt4.imshow(np.add(imgxBiel, imgyBiel), cmap='gray', vmin=0, vmax=255)
    plt5.imshow(np.add(imgxLena, imgyLena), cmap='gray', vmin=0, vmax=255)
    plt6.imshow(np.add(imgxCameraman, imgyCameraman), cmap='gray', vmin=0,␣
 ↪vmax=255)
    plt.show()
    plt.figure()


def gradiente_scipy(img):
    imgBiel = Image.open(img[0])
    f_imgBiel = asarray(imgBiel)
    imgLena = Image.open(img[1])
    f_imgLena = asarray(imgLena)
    imgCameraman = Image.open(img[2])
    f_imgCameraman = asarray(imgCameraman)
    kernelx = masks('sobelx')
    kernely = masks('sobely')
    imgxBiel = convolution_scipy(f_imgBiel, kernelx)
    imgyBiel = convolution_scipy(f_imgBiel, kernely)
    imgxLena = convolution_scipy(f_imgLena, kernelx)
    imgyLena = convolution_scipy(f_imgLena, kernely)
    imgxCameraman = convolution_scipy(f_imgCameraman, kernelx)
    imgyCameraman = convolution_scipy(f_imgCameraman, kernely)
    plt.subplots_adjust(wspace=0.2, hspace=0.01)

    plt.figure(figsize=(24, 12))

    plt1 = plt.subplot(2,3,1)
    plt2 = plt.subplot(2,3,2)
    plt3 = plt.subplot(2,3,3)
    plt4 = plt.subplot(2,3,4)
    plt5 = plt.subplot(2,3,5)
    plt6 = plt.subplot(2,3,6)

    plt3.set_title('Biel')
    plt1.set_title('Lena')
    plt2.set_title('Cameraman')
    print('Gradiente: sobelx + sobely')
    plt1.imshow(imgBiel, cmap='gray', vmin=0, vmax=255)
    plt2.imshow(imgLena, cmap='gray', vmin=0, vmax=255)
    plt3.imshow(imgCameraman, cmap='gray', vmin=0, vmax=255)
    plt4.imshow(np.add(imgxBiel, imgyBiel), cmap='gray', vmin=0, vmax=255)
    plt5.imshow(np.add(imgxLena, imgyLena), cmap='gray', vmin=0, vmax=255)
    plt6.imshow(np.add(imgxCameraman, imgyCameraman), cmap='gray', vmin=0, vmax=255)
    plt.show()
    plt.figure()

def gradiente_manual(img):
    imgBiel = Image.open(img[0])
    f_imgBiel = asarray(imgBiel)
    imgLena = Image.open(img[1])
    f_imgLena = asarray(imgLena)
    imgCameraman = Image.open(img[2])
    f_imgCameraman = asarray(imgCameraman)
    kernelx = masks('sobelx')
    kernely = masks('sobely')
    imgxBiel = convolution_manual(f_imgBiel, kernelx)
    imgyBiel = convolution_manual(f_imgBiel, kernely)
    imgxLena = convolution_manual(f_imgLena, kernelx)
    imgyLena = convolution_manual(f_imgLena, kernely)
    imgxCameraman = convolution_manual(f_imgCameraman, kernelx)
    imgyCameraman = convolution_manual(f_imgCameraman, kernely)
    plt.subplots_adjust(wspace=0.2, hspace=0.01)

    plt.figure(figsize=(24, 12))
    plt1 = plt.subplot(2,3,1)
    plt2 = plt.subplot(2,3,2)
    plt3 = plt.subplot(2,3,3)
    plt4 = plt.subplot(2,3,4)
    plt5 = plt.subplot(2,3,5)
    plt6 = plt.subplot(2,3,6)

    plt3.set_title('Biel')
    plt1.set_title('Lena')
    plt2.set_title('Cameraman')
    print('Gradiente: sobelx + sobely')
    plt1.imshow(imgBiel, cmap='gray', vmin=0, vmax=255)
    plt2.imshow(imgLena, cmap='gray', vmin=0, vmax=255)
    plt3.imshow(imgCameraman, cmap='gray', vmin=0, vmax=255)
    plt4.imshow(np.add(imgxBiel, imgyBiel), cmap='gray', vmin=0, vmax=255)
    plt5.imshow(np.add(imgxLena, imgyLena), cmap='gray', vmin=0, vmax=255)
    plt6.imshow(np.add(imgxCameraman, imgyCameraman), cmap='gray', vmin=0,␣
↪vmax=255)
    plt.show()
    plt.figure()
```

2.1.4 laplace_plus_original_opencv() :: void

função responsável por aplicar o filtro de laplace somado a imagem original utilizando a biblioteca OPENCV.

2.1.5 laplace_plus_original_scipy() :: void

função responsável por aplicar o filtro de laplace somado a imagem original utilizando a biblioteca Scipy.

2.1.6 laplace_plus_original_manual() :: void

função responsável por aplicar o filtro de laplace somado a imagem original utilizando a implementação manual.

[31]:
```
def laplace_plus_original_opencv(img):
    imgBiel = cv2.imread(img[0], cv2.IMREAD_GRAYSCALE)
    imgLena = cv2.imread(img[1], cv2.IMREAD_GRAYSCALE)
    imgCameraman = cv2.imread(img[2], cv2.IMREAD_GRAYSCALE)
    kernel = masks('laplaciano')
    imgxBiel = convolution_opencv(imgBiel, kernel)
    imgxLena = convolution_opencv(imgLena, kernel)
    imgxCameraman = convolution_opencv(imgCameraman, kernel)
    plt.subplots_adjust(wspace=0.2, hspace=0.01)

    plt.figure(figsize=(24, 12))
    plt1 = plt.subplot(2,3,1)
    plt2 = plt.subplot(2,3,2)
    plt3 = plt.subplot(2,3,3)
    plt4 = plt.subplot(2,3,4)
    plt5 = plt.subplot(2,3,5)
    plt6 = plt.subplot(2,3,6)

    plt3.set_title('Biel')
    plt1.set_title('Lena')
    plt2.set_title('Cameraman')
    print('Laplaciano + Original')
    plt1.imshow(imgBiel, cmap='gray', vmin=0, vmax=255)
    plt2.imshow(imgLena, cmap='gray', vmin=0, vmax=255)
    plt3.imshow(imgCameraman, cmap='gray', vmin=0, vmax=255)
    plt4.imshow(np.add(imgBiel, imgxBiel), cmap='gray', vmin=0, vmax=255)
    plt5.imshow(np.add(imgLena, imgxLena), cmap='gray', vmin=0, vmax=255)
    plt6.imshow(np.add(imgCameraman, imgxCameraman), cmap='gray', vmin=0,␣
 ↪vmax=255)
    plt.show()

def laplace_plus_original_scipy(img):
    imgBiel = Image.open(img[0])
    f_imgBiel = asarray(imgBiel)
    imgLena = Image.open(img[1])
    f_imgLena = asarray(imgLena)
    imgCameraman = Image.open(img[2])
    f_imgCameraman = asarray(imgCameraman)
    kernel = masks('laplaciano')
    imgxBiel = convolution_scipy(f_imgBiel, kernel)
    imgxLena = convolution_scipy(f_imgLena, kernel)
    imgxCameraman = convolution_scipy(f_imgCameraman, kernel)
    plt.subplots_adjust(wspace=0.2, hspace=0.01)

    plt.figure(figsize=(24, 12))
    plt1 = plt.subplot(2,3,1)
    plt2 = plt.subplot(2,3,2)
    plt3 = plt.subplot(2,3,3)
    plt4 = plt.subplot(2,3,4)
    plt5 = plt.subplot(2,3,5)
    plt6 = plt.subplot(2,3,6)

    plt3.set_title('Biel')
    plt1.set_title('Lena')
    plt2.set_title('Cameraman')
    print('Laplaciano + Original')
    plt1.imshow(imgBiel, cmap='gray', vmin=0, vmax=255)
    plt2.imshow(imgLena, cmap='gray', vmin=0, vmax=255)
    plt3.imshow(imgCameraman, cmap='gray', vmin=0, vmax=255)
    plt4.imshow(np.add(f_imgBiel, imgxBiel), cmap='gray', vmin=0, vmax=255)
    plt5.imshow(np.add(f_imgLena, imgxLena), cmap='gray', vmin=0, vmax=255)
    plt6.imshow(np.add(f_imgCameraman, imgxCameraman), cmap='gray', vmin=0, vmax=255)
    plt.show()

def laplace_plus_original_manual(img):
    imgBiel = Image.open(img[0])
    f_imgBiel = asarray(imgBiel)
    imgLena = Image.open(img[1])
    f_imgLena = asarray(imgLena)
    imgCameraman = Image.open(img[2])
    f_imgCameraman = asarray(imgCameraman)
    kernel = masks('laplaciano')
    imgxBiel = convolution_manual(f_imgBiel, kernel)
    imgxLena = convolution_manual(f_imgLena, kernel)
    imgxCameraman = convolution_manual(f_imgCameraman, kernel)
    plt.subplots_adjust(wspace=0.2, hspace=0.01)

    plt.figure(figsize=(24, 12))
    plt1 = plt.subplot(2,3,1)
    plt2 = plt.subplot(2,3,2)
    plt3 = plt.subplot(2,3,3)
    plt4 = plt.subplot(2,3,4)
    plt5 = plt.subplot(2,3,5)
    plt6 = plt.subplot(2,3,6)

    plt3.set_title('Biel')
    plt1.set_title('Lena')
    plt2.set_title('Cameraman')
    print('Laplaciano + Original')
    plt1.imshow(imgBiel, cmap='gray', vmin=0, vmax=255)
    plt2.imshow(imgLena, cmap='gray', vmin=0, vmax=255)
    plt3.imshow(imgCameraman, cmap='gray', vmin=0, vmax=255)
    f_imgBiel = cv2.resize(f_imgBiel, (imgxBiel.shape[1], imgxBiel.shape[0]))
    f_imgLena = cv2.resize(f_imgLena, (imgxLena.shape[1], imgxLena.shape[0]))
    f_imgCameraman = cv2.resize(f_imgCameraman, (imgxCameraman.shape[1],␣
↪imgxCameraman.shape[0]))
    plt4.imshow(np.add(f_imgBiel, imgxBiel), cmap='gray', vmin=0, vmax=255)
    plt5.imshow(np.add(f_imgLena, imgxLena), cmap='gray', vmin=0, vmax=255)
    plt6.imshow(np.add(f_imgCameraman, imgxCameraman), cmap='gray', vmin=0,␣
↪vmax=255)
    plt.show()
```

2.1.7 execute_filters_convolution_opencv() :: void

função responsável por executar todas as máscaras de convolução utilizando a biblioteca OPENCV.

2.1.8 execute_filters_convolution_scipy() :: void

função responsável por executar todas as máscaras de convolução utilizando a biblioteca Scipy.

2.1.9 execute_filters_convolution_manual() :: void

função responsável por executar todas as máscaras de convolução utilizando a implementação manual.

[32]:

```
mascaras = ['identidade', 'média', 'gauss', 'laplaciano', 'sobelX', 'sobelY',␣
↪'prewittX', 'prewittY', 'robertsX', 'robertsY', 'boost']
def execute_filters_convolution_opencv():
    for mascara in mascaras:
        print_final_result('biel.png', 'lena_gray_512.tif', 'cameraman.tif',␣
↪mascara, convolution_opencv, 'opencv')
    gradiente_opencv(['biel.png', 'lena_gray_512.tif', 'cameraman.tif'])
    laplace_plus_original_opencv(['biel.png', 'lena_gray_512.tif', 'cameraman.
↪tif'])
def execute_filters_convolution_scipy():
    for mascara in mascaras:
        print_final_result('biel.png', 'lena_gray_512.tif', 'cameraman.tif',␣
↪mascara, convolution_scipy, 'scipy')
    gradiente_scipy(['biel.png', 'lena_gray_512.tif', 'cameraman.tif'])
    laplace_plus_original_scipy(['biel.png', 'lena_gray_512.tif', 'cameraman.
↪tif'])
def execute_filters_convolution_manual():
    for mascara in mascaras:
        print_final_result('biel.png', 'lena_gray_512.tif', 'cameraman.tif',␣
↪mascara, convolution_manual, 'manual')
    gradiente_manual(['biel.png', 'lena_gray_512.tif', 'cameraman.tif'])
    laplace_plus_original_manual(['biel.png', 'lena_gray_512.tif', 'cameraman.
↪tif'])
```

[ ]:

```
def main():
    print('IMPLEMENTAÇÃO DE FILTROS DE CONVOLUÇÃO UTILIZANDO OPENCV')
    execute_filters_convolution_opencv()
```

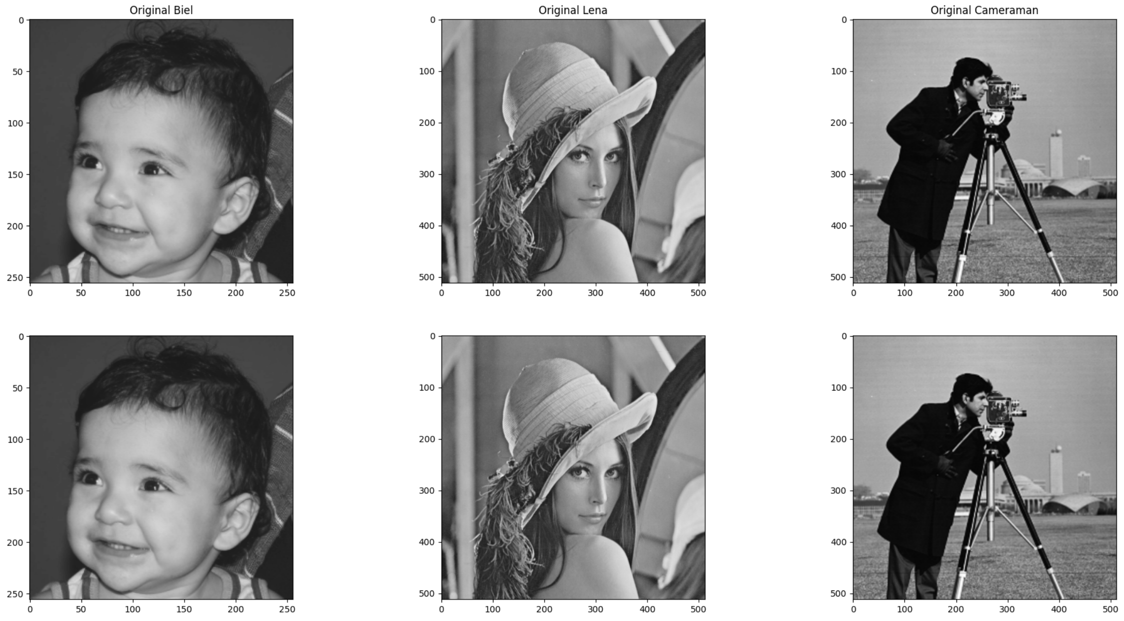
```python
    print('IMPLEMENTAÇÃO DE FILTROS DE CONVOLUÇÃO UTILIZANDO SCIPY')
    execute_filters_convolution_scipy()
    print('IMPLEMENTAÇÃO DE FILTROS DE CONVOLUÇÃO UTILIZANDO IMPLEMENTAÇÃO MANUAL')
    execute_filters_convolution_manual()

if __name__ == "__main__":
    main()
```

```
IMPLEMENTAÇÃO DE FILTROS DE CONVOLUÇÃO UTILIZANDO OPENCV
IDENTIDADE
```

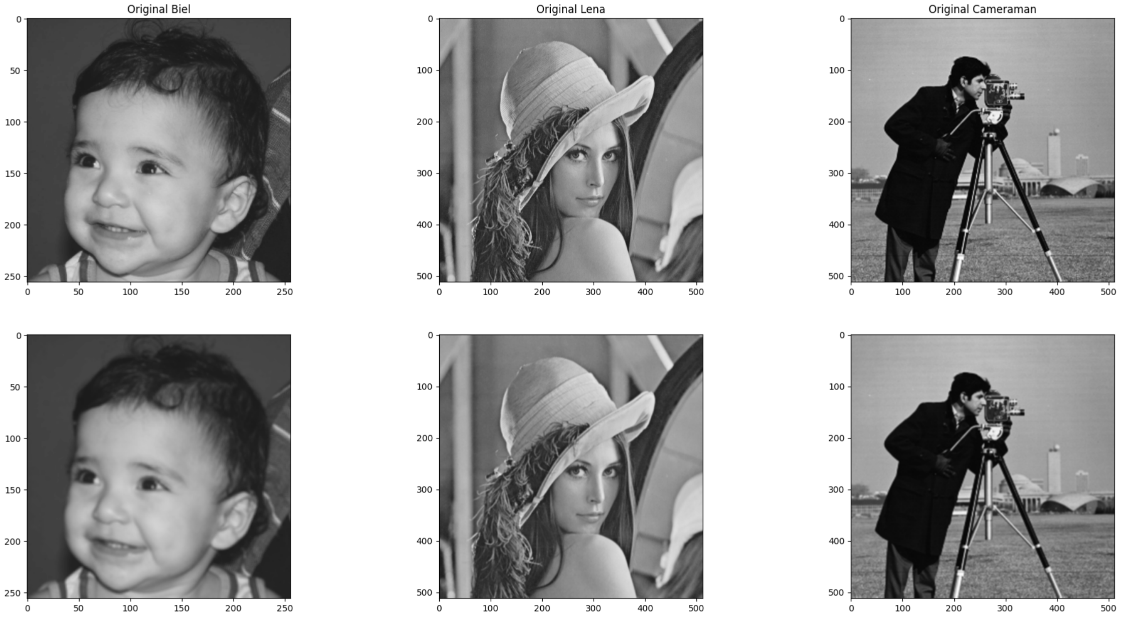
```
<ipython-input-26-20940c6f9264>:29: FutureWarning: elementwise comparison
failed; returning scalar instead, but in the future will perform elementwise
comparison
  if mascara != 'Máscara não encontrada':
```

```
<Figure size 640x480 with 0 Axes>
```



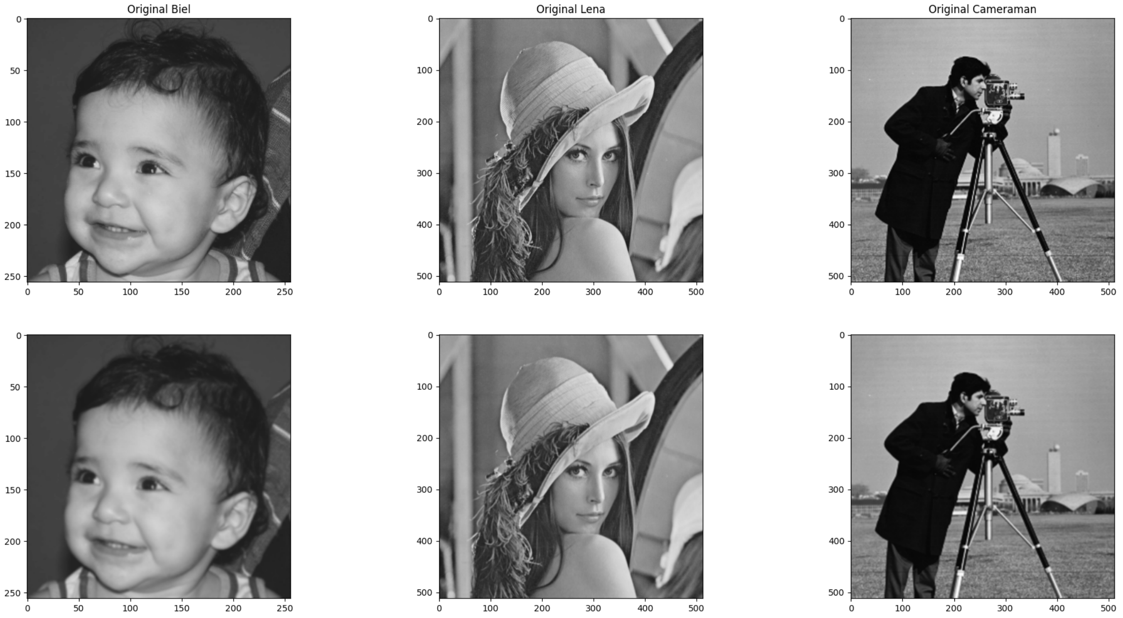
```
MÉDIA
```

```
<Figure size 640x480 with 0 Axes>
```



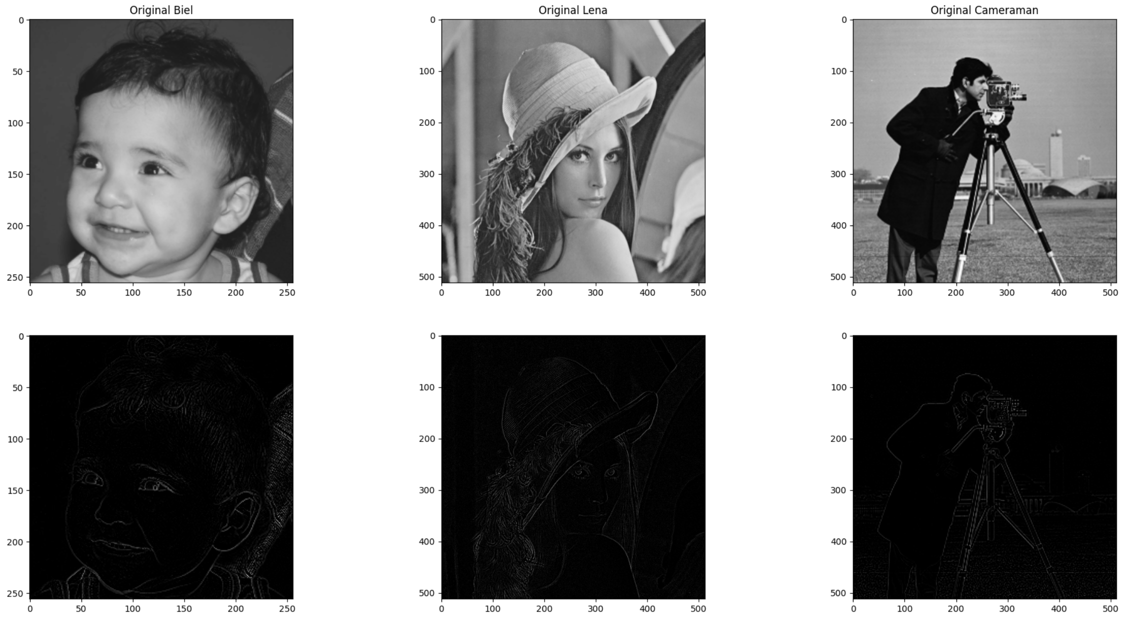
```
GAUSS
```

```
<Figure size 640x480 with 0 Axes>
```

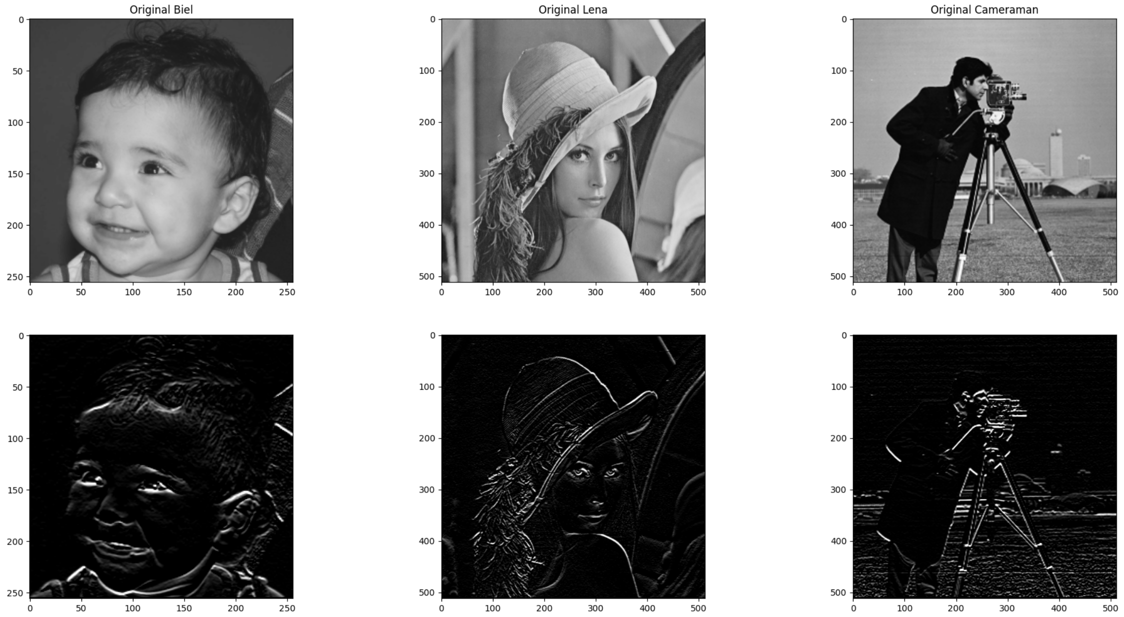


```
LAPLACIANO
```

```
<Figure size 640x480 with 0 Axes>
```


Original Biel
Original Lena
Original Cameraman
0
50
100
150
200
250
0
100
200
300
400
500

```
SOBELX
<Figure size 640x480 with 0 Axes>
```


Original Biel
Original Lena
Original Cameraman
0
50
100
150
200
250
0
100
200
300
400
500