Question 11

Write a program to implement both mode and median filtering operation and applying it on gray scale noisy image. Show the filtering effect for variable window size.

Show that the median filtering results are equivalent i.e. output image obtained after applying 3×3 window twice is equivalent applying 5×5 window once.

In [1]:

```
import numpy as np
import matplotlib.pyplot as plt
import random
from scipy import stats
```

Images to process

In [2]:

```
path_inp = '../../images/dat/'  # path for input files
path_out_orig = 'originals/'    # path for output files: originals
path_out_conv = 'converted/'    # path for output files: converted

filenames = [
    'f256',
    'l256',
    'o256'
]

ext_inp = '.dat'    # file extention for input
ext_out = '.bmp'    # file extention for output
```

Convert images to numpy array and store in a list of tuples as (filename, np.array)

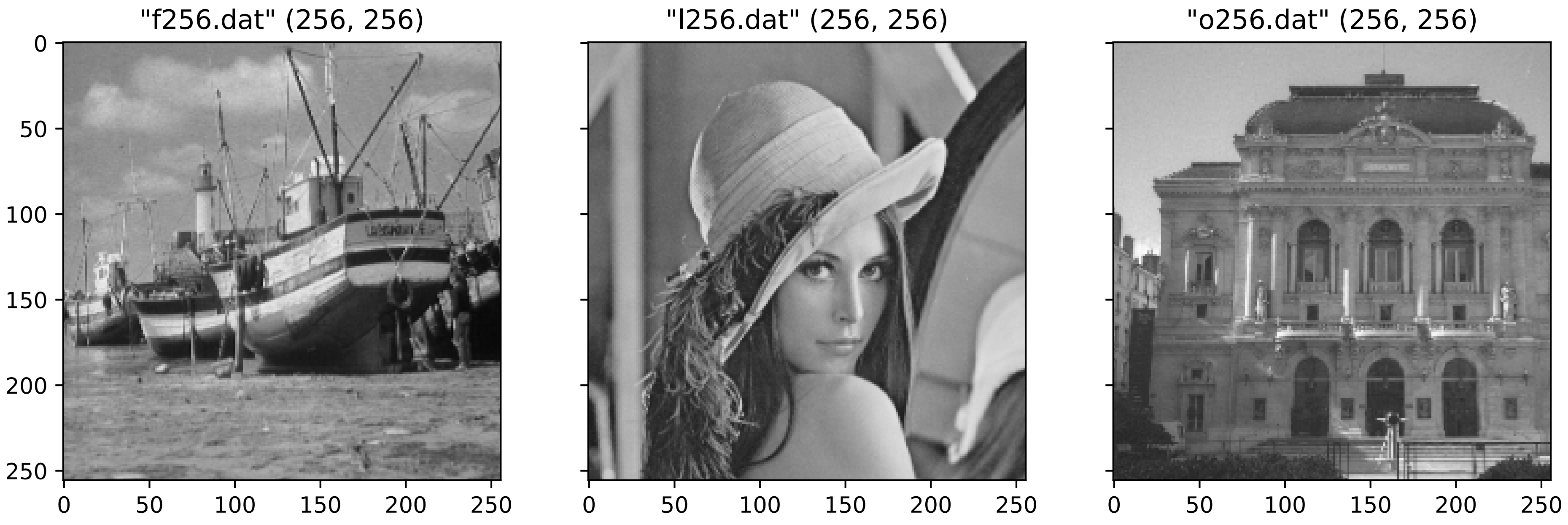
In [3]:

```
# Stores the list of dictionaries for the filename, original image, converted image/s
images = []

# Iterate for all filenames
for idx, filename in enumerate(filenames):
    # Store image pixels as uint8 2D array
    image = np.array(
        [i.strip().split() for i in open(path_inp + filename + ext_inp).readlines()],
        dtype='uint8'
    )

    # Add (filename, numpy array of image) into images list
    images.append({
        'filename': filename,
        'orig': image,
        'equalized': None
    })

    # Save original image as .dat file
    np.savetxt(
        path_out_orig + ext_inp[1:] + '/' + filename + ext_inp,
        image,
        fmt=' %d',
        newline=' \n'
    )
```

Display input images

In [4]:

```
# Matrix dimensions
cols = 3
rows = 1

# Create figure with rows × cols subplots
fig, axs = plt.subplots(rows, cols, dpi=80, sharex=True, sharey=True)
fig.set_size_inches(4 * cols, 4.5 * rows)

# Iterate for all images
for idx, image_dict in enumerate(images):
    filename = image_dict['filename']
    image = image_dict['orig']

    # Set subplot title as '"filename" (rows, cols)'
    axs[idx].set_title('"{}" {}'.format(
        filename + ext_inp,
        image.shape
    ))
    # Add subplot to figure plot buffer
    axs[idx].imshow(
        image,
        cmap='gray',
        vmin=0,
        vmax=255
    )
    # Save original image as .bmp file
    plt.imsave(
        path_out_orig + ext_out[1:] + '/' + filename + ext_out,
        image,
        cmap='gray',
        vmin=0,
        vmax=255
    )

# Hide x labels and tick labels for top plots and y ticks for right plots
for ax in axs.flat:
    ax.label_outer()

# Display the figure
plt.show()
```



Additive Noise Corruption

In [5]:

```
def add_noise(image, p: int, q: int):
    height, width = image.shape

    n_pixels = height * width
    n_p = (n_pixels * p) // 100
    pixels = set()
    for i in range(n_p):
        while True:
            curr = random.randint(0, n_pixels - 1)
            row = curr // width
            col = curr % width
            if (row, col) not in pixels:
                pixels.add((row, col))
                break

    noisy_image = np.zeros((height, width))

    def min(a, b):
        return a if a < b else b

    for i in range(height):
        for j in range(width):
            noisy_image[i][j] = image[i][j]

    for row, col in pixels:
        noisy_image[row][col] = min(
            255,
            int(noisy_image[row][col]) + int(image[row][col] * (random.randint(0, q) / 100))
        )

    noisy_image = noisy_image.astype('uint8')

    return noisy_image
```

Image Difference

In [6]:

```
def difference_image(image_a, image_b):
    height, width = image_a.shape
    img = abs(image_a - image_b)
    for i in range(height):
        for j in range(width):
            img[i][j] = 0 if img[i][j] < 0 else img[i][j]
    return img
```

Image Filtering

In [7]:

```
def mode(elems):
    return stats.mode(elems)[0][0]
```

```
def median(elems):
    return np.median(elems)
```

In [8]:

```
def filter_img(image, operation, w_size):
    height, width = image.shape
    img = np.zeros(image.shape)

    def get_pixel(i, j):
        return image[i][j] if (i >= 0 and j >=0) and (i < height and j < width) else 0

    p_list = list(range(w_size))
    for i in range(w_size):
        p_list[i] -= w_size // 2

    for i in range(height):
        for j in range(width):
            elems = []
            for m in p_list:
                for n in p_list:
                    elems.append(get_pixel(i + m, j + n))
            img[i][j] = operation(elems)
    img.astype('uint8')

    return img
```

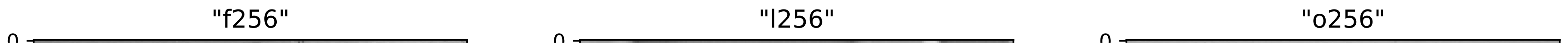
In [9]:

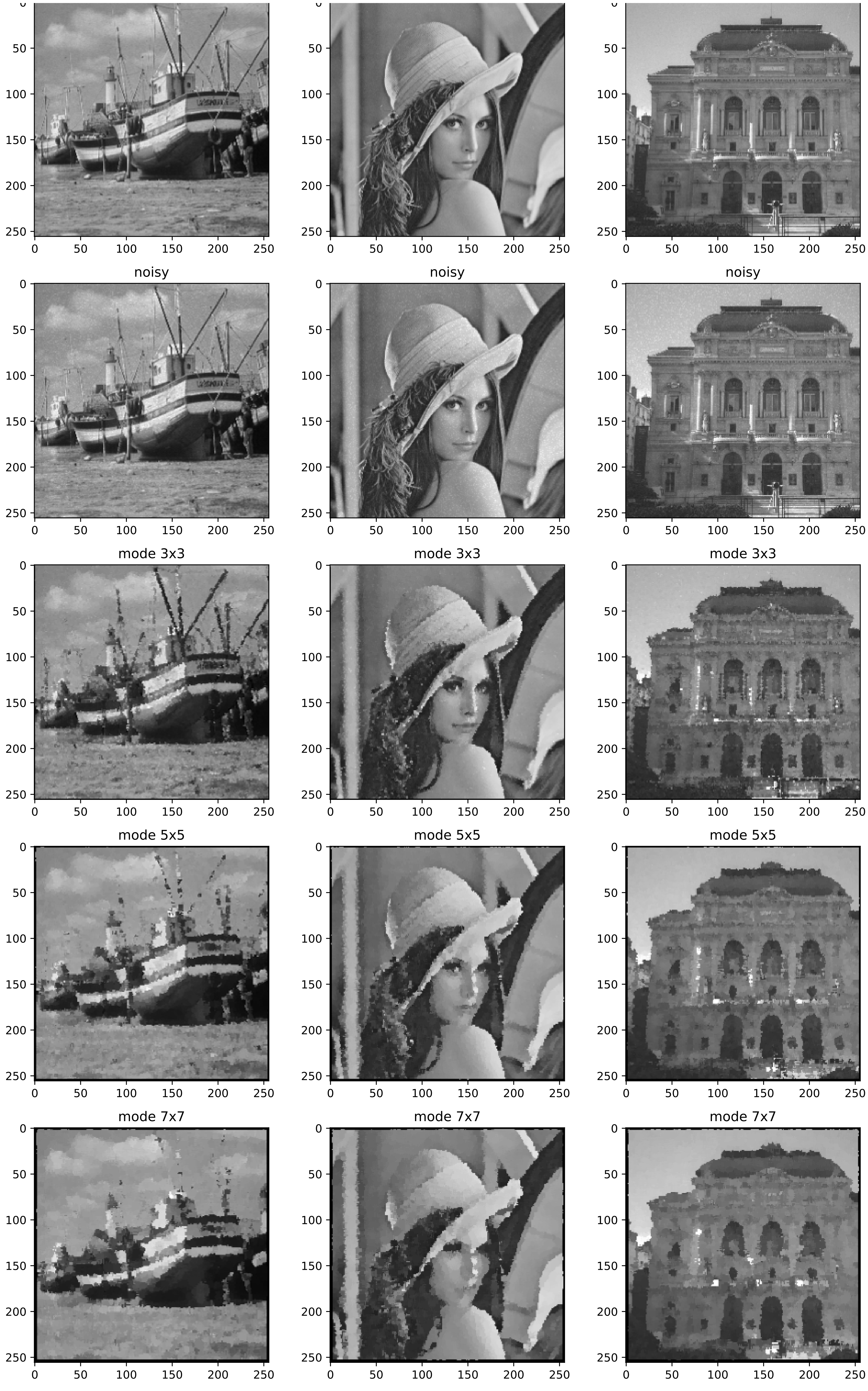
```
def save_dat(filename, data):
    np.savetxt(
        path_out_conv + ext_inp[1:] + '/' + filename + ext_inp,
        data,
        fmt=' %d',
        newline=' \n'
    )

def save_img(filename, image):
    plt.imsave(
        path_out_conv + ext_out[1:] + '/' + filename + ext_out,
        image,
        cmap='gray',
        vmin=0,
        vmax=255
    )
```

Mode Filtering

In [10]:

```
rows, cols = 5, len(images)

# Create figure with rows × cols subplots
fig, axs = plt.subplots(rows, cols, dpi=80)
fig.set_size_inches(4.5 * cols, 4.5 * rows)

# Iterate for all images
for idx, image_dict in enumerate(images):
    filename = image_dict['filename']

    orig = image_dict['orig']
    noisy = add_noise(orig, 25, 15)

    axs[0, idx].set_title(f'"{filename}"')
    axs[0, idx].imshow(orig, cmap='gray', vmin=0, vmax=255)

    axs[1, idx].set_title(f'noisy')
    axs[1, idx].imshow(noisy, cmap='gray', vmin=0, vmax=255)
    save_dat(filename + f'_noisy', noisy)
    save_img(filename + f'_noisy', noisy)

    mode_3 = filter_img(noisy, mode, 3)
    axs[2, idx].set_title(f'mode 3x3')
    axs[2, idx].imshow(mode_3, cmap='gray', vmin=0, vmax=255)
    save_dat(filename + f'_mode_3', mode_3)
    save_img(filename + f'_mode_3', mode_3)

    mode_5 = filter_img(noisy, mode, 5)
    axs[3, idx].set_title(f'mode 5x5')
    axs[3, idx].imshow(mode_5, cmap='gray', vmin=0, vmax=255)
    save_dat(filename + f'_mode_5', mode_5)
    save_img(filename + f'_mode_5', mode_5)

    mode_7 = filter_img(noisy, mode, 7)
    axs[4, idx].set_title(f'mode 7x7')
    axs[4, idx].imshow(mode_7, cmap='gray', vmin=0, vmax=255)
    save_dat(filename + f'_mode_7', mode_7)
    save_img(filename + f'_mode_7', mode_7)

# Save and display the figure
plt.savefig('mode_filter.jpg')
plt.show()
```

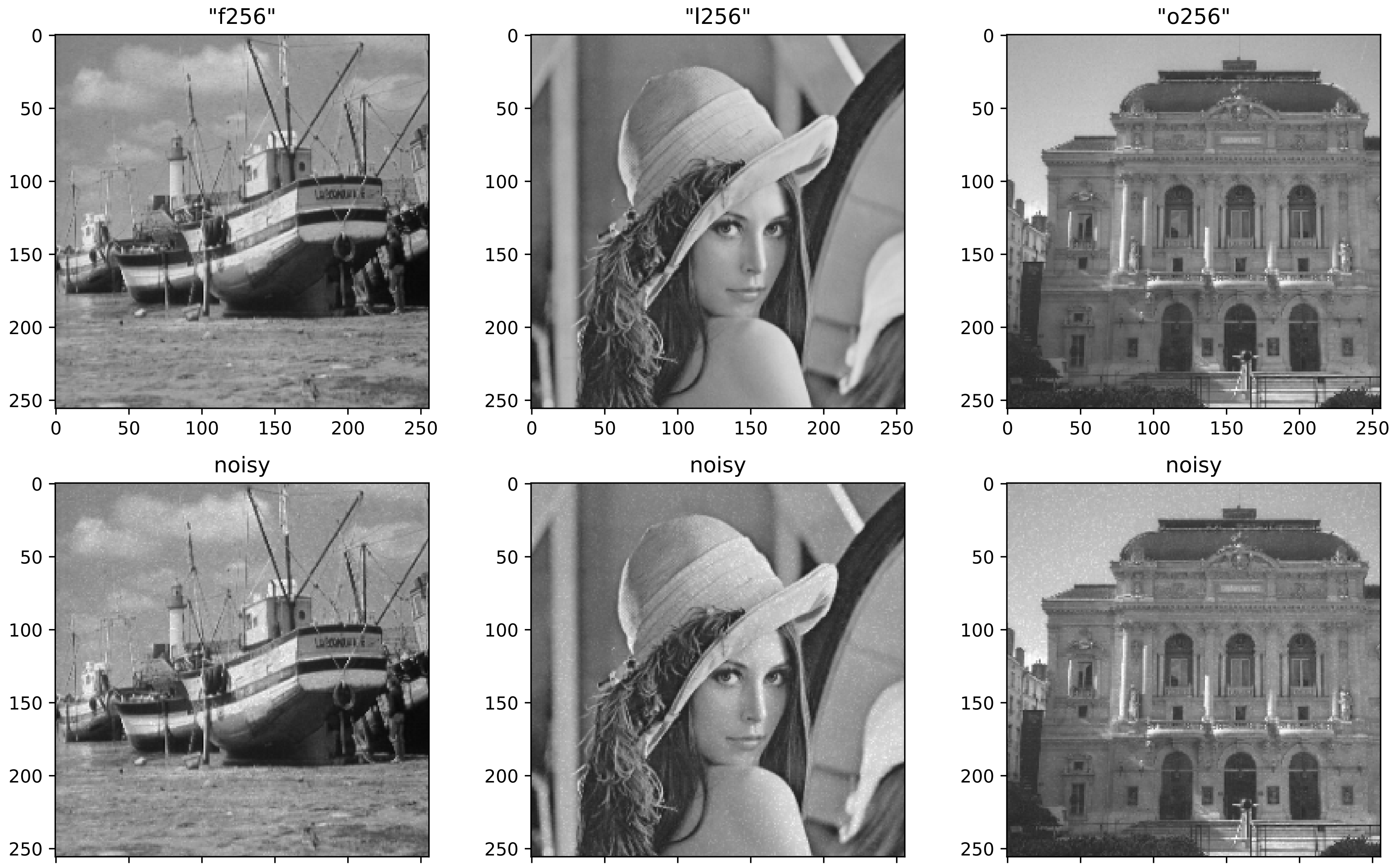


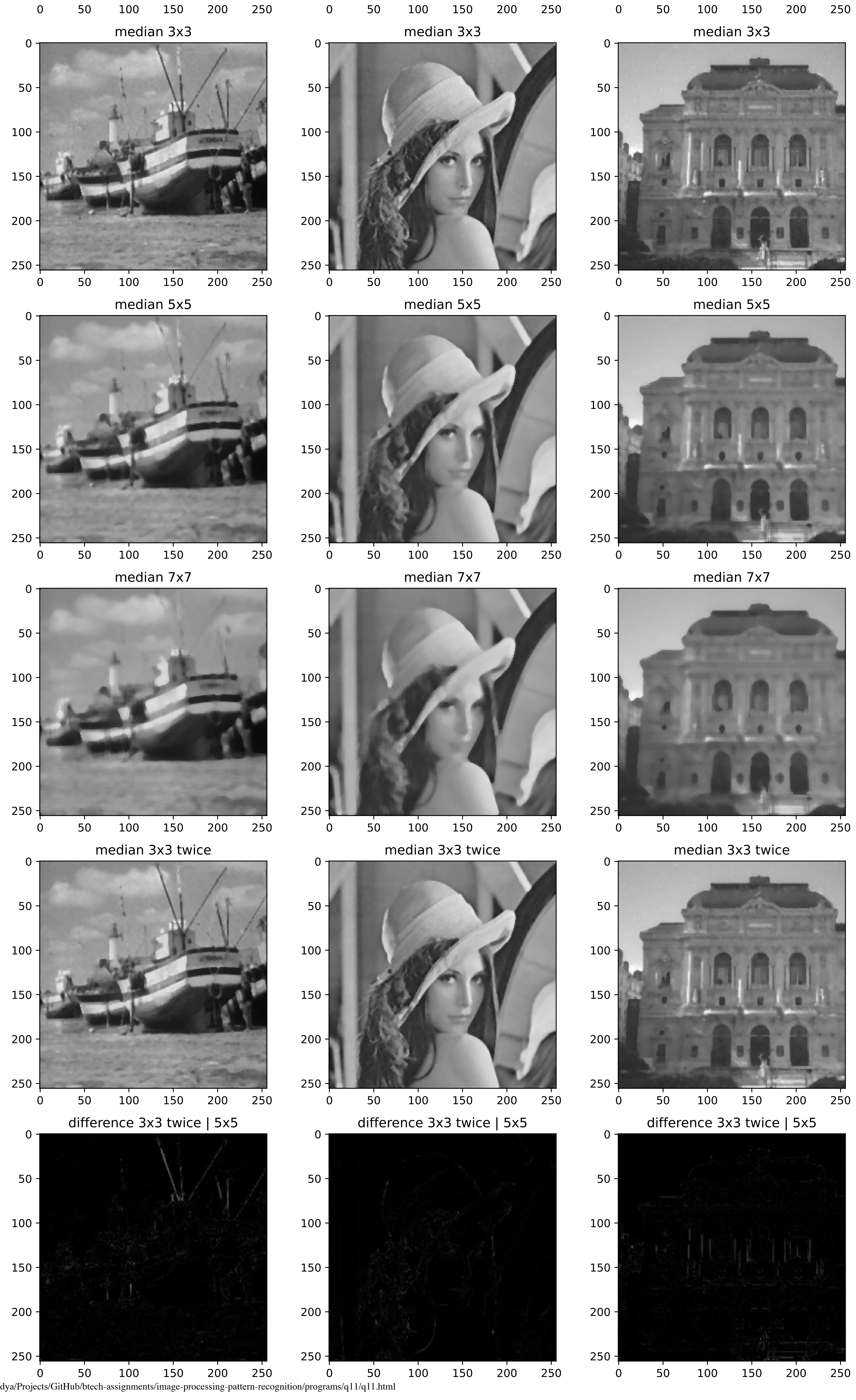

noisy
noisy
noisy
mode 3x3
mode 3x3
mode 3x3
mode 5x5
mode 5x5
mode 5x5
mode 7x7
mode 7x7
mode 7x7
0
50
100
150
200
250

Median Filtering

In [11]:

```
rows, cols = 7, len(images)

# Create figure with rows × cols subplots
fig, axs = plt.subplots(rows, cols, dpi=80)
fig.set_size_inches(4.5 * cols, 4.5 * rows)

# Iterate for all images
for idx, image_dict in enumerate(images):
    filename = image_dict['filename']

    orig = image_dict['orig']
    noisy = add_noise(orig, 25, 15)

    axs[0, idx].set_title(f'"{filename}"')
    axs[0, idx].imshow(orig, cmap='gray', vmin=0, vmax=255)

    axs[1, idx].set_title(f'noisy')
    axs[1, idx].imshow(noisy, cmap='gray', vmin=0, vmax=255)
    save_dat(filename + f'_noisy', noisy)
    save_img(filename + f'_noisy', noisy)

    median_3 = filter_img(noisy, median, 3)
    axs[2, idx].set_title(f'median 3x3')
    axs[2, idx].imshow(median_3, cmap='gray', vmin=0, vmax=255)
    save_dat(filename + f'_median_3', median_3)
    save_img(filename + f'_median_3', median_3)

    median_5 = filter_img(noisy, median, 5)
    axs[3, idx].set_title(f'median 5x5')
    axs[3, idx].imshow(median_5, cmap='gray', vmin=0, vmax=255)
    save_dat(filename + f'_median_5', median_5)
    save_img(filename + f'_median_5', median_5)

    median_7 = filter_img(noisy, median, 7)
    axs[4, idx].set_title(f'median 7x7')
    axs[4, idx].imshow(median_7, cmap='gray', vmin=0, vmax=255)
    save_dat(filename + f'_median_7', median_7)
    save_img(filename + f'_median_7', median_7)

    median_3_x2 = filter_img(filter_img(noisy, median, 3), median, 3)
    axs[5, idx].set_title(f'median 3x3 twice')
    axs[5, idx].imshow(median_3_x2, cmap='gray', vmin=0, vmax=255)
    save_dat(filename + f'_median_3_x2', median_3_x2)
    save_img(filename + f'_median_3_x2', median_3_x2)

    diff = difference_image(median_5, median_3_x2)
    axs[6, idx].set_title(f'difference 3x3 twice | 5x5')
    axs[6, idx].imshow(diff, cmap='gray', vmin=0, vmax=255)
    save_dat(filename + f'_diff_5__3_x2', diff)
    save_img(filename + f'_diff_5__3_x2', diff)

# Save and display the figure
plt.savefig('median_filter.jpg')
plt.show()
```




median 3x3
median 3x3
median 3x3
median 5x5
median 5x5
median 5x5
median 7x7
median 7x7
median 7x7
median 3x3 twice
median 3x3 twice
median 3x3 twice
difference 3x3 twice | 5x5
difference 3x3 twice | 5x5
difference 3x3 twice | 5x5
0
50
100
150
200
250