Department of Computer Science and Engineering (Data Science)
Image Processing and Computer Vision I (DJ19DSL603)

Lab 5: Image Enhancement in Spatial Domain using Neighbourhood Processing Techniques

Name:Jhanvi Parekh
Sap:60009210033

Aim: To perform image enhancement in spatial domain using neighbourhood processing techniques: Basic High Pass and High Boost filtering

Theory:

1. **Basic High Pass:**

The principal objective of high pass (sharpening) filter is to highlight fine detail in an image or to enhance detail that has been blurred, either in error or as a natural effect of a particular method of image acquisition. Uses of image sharpening vary and include applications ranging from electronic printing and medical imaging to industrial inspection and autonomous target detection in military systems.

The shape of the impulse response needed to have a high pass (sharpening) spatial filter indicates that the filter should have positive coefficients in the outer periphery. For a 3 x 3 mask, choosing a positive value in the centre location with negative coefficients in the rest of the mask meets this condition. Thus when the mask is over an area of constant or slowly varying gray level, the output of the mask is zero or very small. This result is consistent with what is expected from the corresponding frequency domain filter.

−1	−1	−1
−1	8	−1
−1	−1	−1

fig 1. A high pass filter mask

2. **High Boost Filter:**

The goal of high boost filtering is to enhance the high frequency information without completely eliminating the background of the image.

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We know that:

(High-pass filtered image)=(Original image)-(Low-pass filtered image)

We define:

(High boost filtered image) = A × (Original image) - (Low-pass filtered image)

(High boost) = (A−1) × (Original) + (Original) - (Low-pass)

(High boost) = (A−1) × (Original) + (High-pass)

Note:

i. when A>1, part of the original is added back to the high-pass filtered version of the image in order to partly restore the lowfrequency components that would have been eliminated with standardhigh-pass filtering.
ii. Typical values for A are values slightly higher than 1, as for example 1.15, 1.2, etc.

The resulting image looks similar to the original image with some edge enhancement.

The spatial mask that implements the high boost filtering algorithm is shown below.

$\frac{1}{9} \times$

-1	-1	-1
-1	$w = 9A - 1$	-1
-1	-1	-1

fig 2. High boost filter mask

The resulting image depends on the choice of A.

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$A = 1.15$ $A = 1.2$

Lab Assignments to complete in this session

Problem Statement: Develop a Python program utilizing the OpenCV library to enhance the images in spatial domain using neighbourhood processing with sharpening operators (High pass filtering and High boost filtering). The program should address the following tasks:

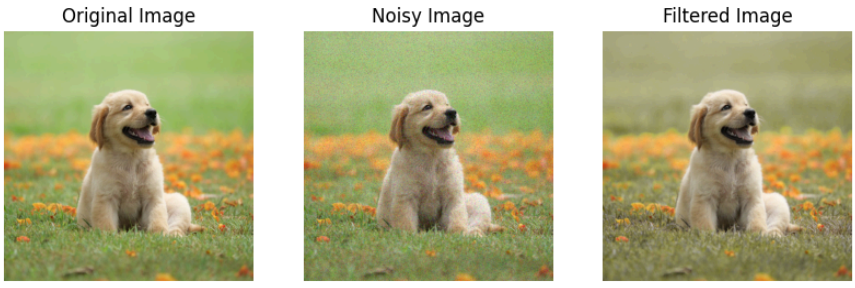
1. Read any low contrast image from COVID 19 Image Dataset.
   Dataset Link: Covid-19 Image Dataset
2. Display the before & after image(s) used in every task below:
   a. Apply basic high pass filter and compare the before and after result.
   b. Apply basic high boost filter and compare the before and after result.

The solution to the operations performed must be produced by scratch coding without the use of built in OpenCV methods.

Google Colab Link :https://colab.research.google.com/drive/1c4BVOLODn1a7icG8n4vm7UfdNMui7DBc?usp=sharing

• Add salt and pepper noise and then perform median filtering

```
import numpy as np
import matplotlib.pyplot as plt
from scipy import ndimage
import numpy as np
import cv2


def add_salt_and_pepper_noise(image, salt_prob, pepper_prob):
    noisy_image = np.copy(image)
    salt_mask = np.random.random(image.shape) < salt_prob
    pepper_mask = np.random.random(image.shape) < pepper_prob
    noisy_image[salt_mask] = 255
    noisy_image[pepper_mask] = 0
    return noisy_image

def median_filter(image, kernel_size):
    filtered_image = ndimage.median_filter(image, size=kernel_size)
    return filtered_image

# Load the image
image_path = "/content/doggie.jpg"
original_image = plt.imread(image_path)

# Add salt and pepper noise
salt_prob = 0.05  # Probability of adding salt noise
pepper_prob = 0.05  # Probability of adding pepper noise
noisy_image = add_salt_and_pepper_noise(original_image, salt_prob, pepper_prob)

# Perform median filtering
kernel_size = 3  # Size of the median filter kernel
filtered_image = median_filter(noisy_image, kernel_size)

# Display the images
plt.figure(figsize=(10, 5))

plt.subplot(1, 3, 1)
plt.imshow(original_image, cmap='gray')
plt.title('Original Image')
plt.axis('off')

plt.subplot(1, 3, 2)
plt.imshow(noisy_image, cmap='gray')
plt.title('Noisy Image')
plt.axis('off')

plt.subplot(1, 3, 3)
plt.imshow(filtered_image, cmap='gray')
plt.title('Filtered Image')
plt.axis('off')

plt.show()
```

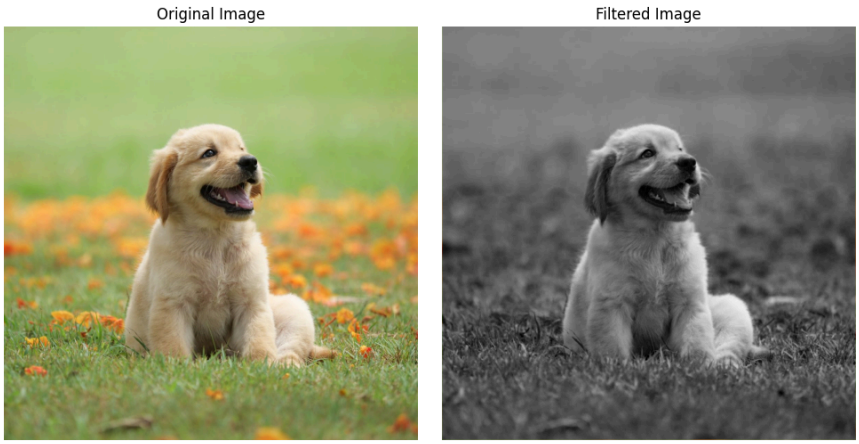



```
def median_filter(image):
    padded_image = np.pad(image, ((1, 1), (1, 1)), mode='edge')  # Use mode='edge' for padding
    print("Shape of padded image:", padded_image.shape)  # Print the shape of the padded image
    filtered_image = np.zeros_like(image)

    for i in range(1, image.shape[0] - 1):
        for j in range(1, image.shape[1] - 1):
            # Extract pixel values
            pixel_values = padded_image[i-1:i+2, j-1:j+2].flatten()
```

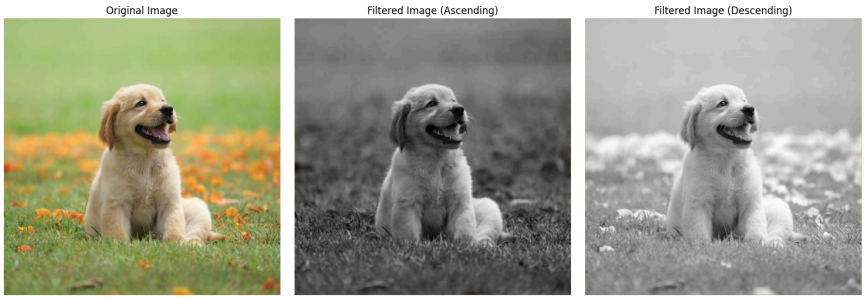
```
            # Sort pixel values
            sorted_values = np.sort(pixel_values)

            # Get median value
            median_value = sorted_values[4]  # 4 is the index of the median value

            # Assign median value to filtered image
            filtered_image[i-1, j-1] = median_value  # Corrected indexing

    return filtered_image


# Load the image
image_path = "/content/doggie.jpg"  # Image path
image = cv2.imread(image_path, cv2.IMREAD_GRAYSCALE)

# Perform median filtering
filtered_image = median_filter(image)

# Display the filtered image using Matplotlib
plt.imshow(filtered_image, cmap='gray')
plt.title('Filtered Image')
plt.axis('off')  # Turn off axis
plt.show()
```

```
Shape of padded image: (1199, 1202)
```

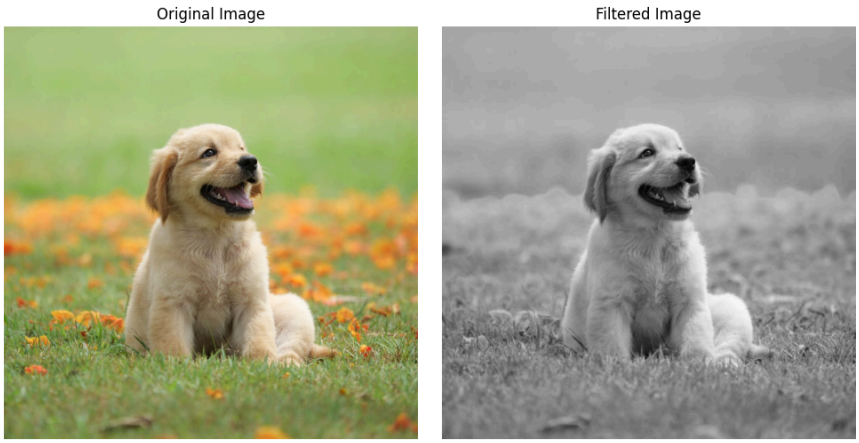
```
def median_filter(image):
    padded_image = cv2.copyMakeBorder(image, 1, 1, 1, 1, cv2.BORDER_REPLICATE)  # Padding the image
    filtered_image = image.copy()

    for i in range(1, image.shape[0] - 1):  # Adjusted loop limits
        for j in range(1, image.shape[1] - 1):  # Adjusted loop limits
            # Extract pixel values
            pixel_values = padded_image[i-1:i+2, j-1:j+2].flatten()

            # Sort pixel values
            sorted_values = sorted(pixel_values)

            # Get median value
            median_value = sorted_values[4]  # 4 is the index of the median value

            # Assign median value to filtered image
            filtered_image[i, j] = median_value

    return filtered_image

# Load the image
image_path = "/content/doggie.jpg"  # Image path
image = cv2.imread(image_path)  # Load image in color mode

# Convert the image to RGB (matplotlib uses RGB)
image_rgb = cv2.cvtColor(image, cv2.COLOR_BGR2RGB)

# Perform median filtering
filtered_image = median_filter(image_rgb)

# Create a figure and set its size
plt.figure(figsize=(10, 5))

# Display the original image on the left-hand side corner
plt.subplot(1, 2, 1)
plt.imshow(image_rgb)
plt.title('Original Image')
plt.axis('off')  # Turn off axis

# Display the filtered image on the right-hand side
plt.subplot(1, 2, 2)
plt.imshow(filtered_image)
plt.title('Filtered Image')
plt.axis('off')  # Turn off axis

# Adjust layout to prevent overlap
plt.tight_layout()

# Show the plot
plt.show()
```



```
def median_filter(image, ascending=True):
    padded_image = cv2.copyMakeBorder(image, 1, 1, 1, 1, cv2.BORDER_REPLICATE)  # Padding the image
    filtered_image = image.copy()

    for i in range(1, image.shape[0] - 1):  # Adjusted loop limits
        for j in range(1, image.shape[1] - 1):  # Adjusted loop limits
            # Extract pixel values
            pixel_values = padded_image[i-1:i+2, j-1:j+2].flatten()

            # Sort pixel values
            if ascending:
                sorted_values = sorted(pixel_values)  # Ascending order
            else:
                sorted_values = sorted(pixel_values, reverse=True)  # Descending order

            # Get median value
            median_value = sorted_values[4]  # 4 is the index of the median value

            # Assign median value to filtered image
            filtered_image[i, j] = median_value

    return filtered_image

# Load the image
image_path = "/content/doggie.jpg"  # Image path
image = cv2.imread(image_path)  # Load image in color mode

# Convert the image to RGB (matplotlib uses RGB)
image_rgb = cv2.cvtColor(image, cv2.COLOR_BGR2RGB)

# Perform median filtering with ascending order
filtered_image_ascending = median_filter(image_rgb, ascending=True)

# Perform median filtering with descending order
filtered_image_descending = median_filter(image_rgb, ascending=False)

# Create a figure and set its size
plt.figure(figsize=(15, 5))

# Display the original image on the left-hand side corner
plt.subplot(1, 3, 1)
plt.imshow(image_rgb)
plt.title('Original Image')
plt.axis('off')  # Turn off axis

# Display the filtered image with ascending order in the middle
plt.subplot(1, 3, 2)
plt.imshow(filtered_image_ascending)
plt.title('Filtered Image (Ascending)')
plt.axis('off')  # Turn off axis

# Display the filtered image with descending order on the right-hand side
plt.subplot(1, 3, 3)
plt.imshow(filtered_image_descending)
plt.title('Filtered Image (Descending)')
plt.axis('off')  # Turn off axis

# Adjust layout to prevent overlap
plt.tight_layout()

# Show the plot
plt.show()
```

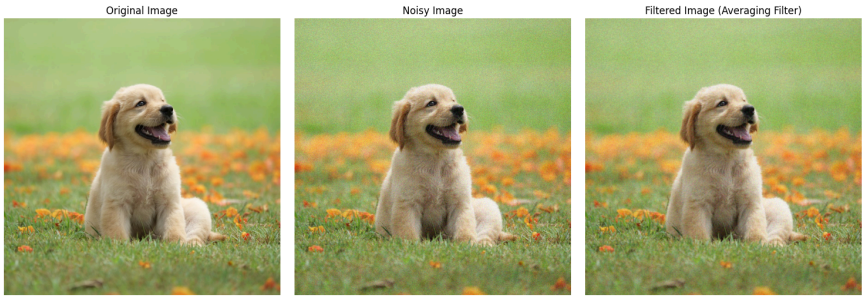



```
def median_filter(image):
    # Create an output image with the same dimensions as the input image
    filtered_image = np.zeros_like(image)

    # Iterate over each pixel in the image
    for i in range(image.shape[0]):
        for j in range(image.shape[1]):
            # Extract a 3x3 neighborhood around the current pixel
            neighborhood = image[max(0, i-1):min(image.shape[0], i+2), max(0, j-1):min(image.shape[1], j+2)]

            # Compute the median of the pixel values in the neighborhood
            median_value = np.median(neighborhood)

            # Assign the median value to the corresponding pixel in the output image
            filtered_image[i, j] = median_value

    return filtered_image

# Load the image
image_path = "/content/doggie.jpg"  # Image path
image = cv2.imread(image_path)  # Load image in color mode

# Perform median filtering
filtered_image = median_filter(image)

# Display the original color image
plt.figure(figsize=(10, 5))

plt.subplot(1, 2, 1)
plt.imshow(cv2.cvtColor(image, cv2.COLOR_BGR2RGB))
plt.title('Original Image')
plt.axis('off')

# Display the filtered image
plt.subplot(1, 2, 2)
plt.imshow(filtered_image, cmap='gray')
plt.title('Filtered Image')
plt.axis('off')

plt.tight_layout()
plt.show()
```

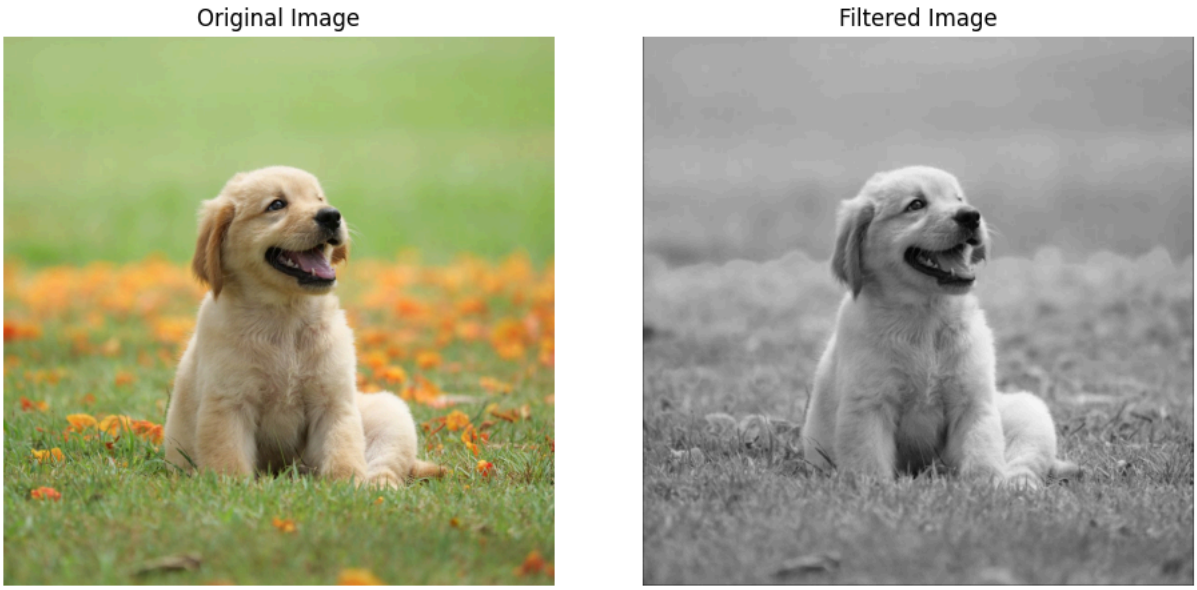


Add Gaussian noise and then perform averaging filter

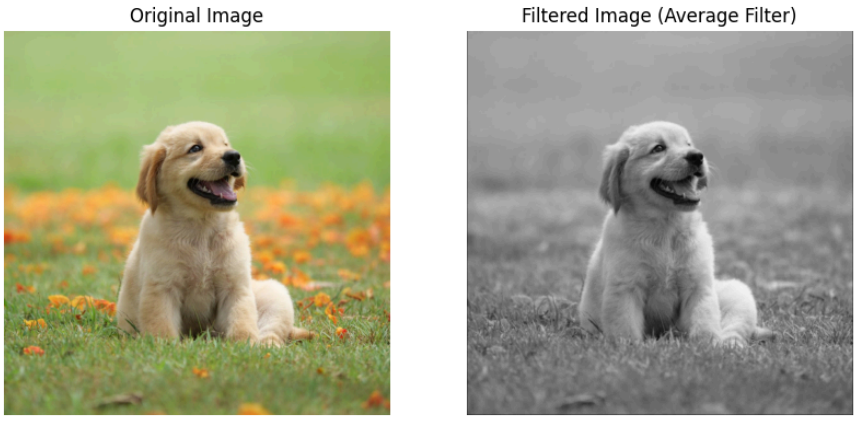
```
def add_gaussian_noise(image, mean=0, sigma=25):
    """Add Gaussian noise to the image."""
    row, col, ch = image.shape
    gauss = np.random.normal(mean, sigma, (row, col, ch))
    gauss = gauss.reshape(row, col, ch)
    noisy_image = image + gauss
    return np.clip(noisy_image, 0, 255).astype(np.uint8)

def average_filter(image, kernel_size=3):
    """Apply an average filter to the image."""
    return cv2.blur(image, (kernel_size, kernel_size))

# Load the image
image_path = "/content/doggie.jpg"
image = cv2.imread(image_path)

# Add Gaussian noise to the image
noisy_image = add_gaussian_noise(image)

# Apply average filtering
filtered_image = average_filter(noisy_image)

# Display original, noisy, and filtered images
plt.figure(figsize=(15, 5))

plt.subplot(1, 3, 1)
plt.imshow(cv2.cvtColor(image, cv2.COLOR_BGR2RGB))
plt.title('Original Image')
plt.axis('off')

plt.subplot(1, 3, 2)
plt.imshow(cv2.cvtColor(noisy_image, cv2.COLOR_BGR2RGB))
plt.title('Noisy Image')
plt.axis('off')

plt.subplot(1, 3, 3)
plt.imshow(cv2.cvtColor(filtered_image, cv2.COLOR_BGR2RGB))
plt.title('Filtered Image (Averaging Filter)')
plt.axis('off')

plt.tight_layout()
plt.show()
```




```
def median_filter(image):
    # Create an output image with the same dimensions as the input image
    filtered_image = np.zeros_like(image)

    # Iterate over each pixel in the image
    for i in range(1, image.shape[0] - 1):
        for j in range(1, image.shape[1] - 1):
            # Extract a 3x3 neighborhood around the current pixel
            neighborhood = image[i - 1:i + 2, j - 1:j + 2]

            # Compute the median of the pixel values in the neighborhood
            median_value = np.median(neighborhood)

            # Assign the median value to the corresponding pixel in the output image
            filtered_image[i, j] = median_value

    return filtered_image

# Load the color image
image_path = "/content/doggie.jpg"
image = cv2.imread(image_path)

# Perform median filtering
filtered_image = median_filter(image)

# Display the original and filtered images
plt.figure(figsize=(10, 5))

plt.subplot(1, 2, 1)
plt.imshow(cv2.cvtColor(image, cv2.COLOR_BGR2RGB))
plt.title('Original Image')
plt.axis('off')

plt.subplot(1, 2, 2)
plt.imshow(cv2.cvtColor(filtered_image, cv2.COLOR_BGR2RGB))
plt.title('Filtered Image')
plt.axis('off')

plt.tight_layout(pad=3.0)  # Adjust padding for better visualization

plt.show()
```



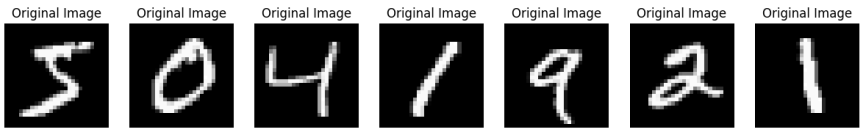

```
def average_filter(image):
    # Create an output image with the same dimensions as the input image
    filtered_image = np.zeros_like(image)

    # Iterate over each pixel in the image
    for i in range(1, image.shape[0] - 1):
        for j in range(1, image.shape[1] - 1):
            # Extract a 3x3 neighborhood around the current pixel
            neighborhood = image[i - 1:i + 2, j - 1:j + 2]

            # Compute the average of the pixel values in the neighborhood
            average_value = np.mean(neighborhood)

            # Assign the average value to the central pixel in the output image
            filtered_image[i, j] = average_value

    return filtered_image

# Load the color image
image_path = "/content/doggie.jpg"
image = cv2.imread(image_path)

# Perform average filtering
filtered_image = average_filter(image)

# Display the original and filtered images
plt.figure(figsize=(10, 5))

plt.subplot(1, 2, 1)
plt.imshow(cv2.cvtColor(image, cv2.COLOR_BGR2RGB))  # Convert BGR to RGB for Matplotlib
plt.title('Original Image')
plt.axis('off')

plt.subplot(1, 2, 2)
plt.imshow(filtered_image, cmap='gray')
plt.title('Filtered Image (Average Filter)')
plt.axis('off')

plt.show()
```



Fashion mnist dataset

```
from tensorflow.keras.datasets import fashion_mnist
```

```
import numpy as np
import cv2
from tensorflow.keras.datasets import mnist
import matplotlib.pyplot as plt

# Load MNIST dataset
(train_images, train_labels), (test_images, test_labels) = mnist.load_data()

# Select a sample of images for processing (e.g., first 5 images)
sample_images = train_images[:7]

# Display original and enhanced images
plt.figure(figsize=(15, 5))
for i in range(len(sample_images)):
    plt.subplot(2, len(sample_images), i + 1)
    plt.imshow(sample_images[i], cmap='gray')
    plt.title('Original Image')
    plt.axis('off')
plt.show()
```



```
import numpy as np
import cv2
from tensorflow.keras.datasets import mnist
import matplotlib.pyplot as plt

def add_salt_pepper_noise(image, salt_prob, pepper_prob):
    noisy_image = image.copy()
    salt_mask = np.random.rand(*image.shape) < salt_prob
    pepper_mask = np.random.rand(*image.shape) < pepper_prob
    noisy_image[salt_mask] = 255
    noisy_image[pepper_mask] = 0
    return noisy_image

def median_filter(image):
    filtered_image = np.zeros_like(image)

    for i in range(1, image.shape[0] - 1):
        for j in range(1, image.shape[1] - 1):
            # Extract pixel values
            pixel_values = image[i-1:i+2, j-1:j+2].flatten()

            # Sort pixel values
            sorted_values = np.sort(pixel_values)

            # Get median value
            median_value = sorted_values[4]  # 4 is the index of the median value

            # Assign median value to filtered image
            filtered_image[i, j] = median_value

    return filtered_image

# Select a sample of images for processing (e.g., first 5 images)
sample_images = train_images[:5]

# Add salt and pepper noise to the images
salt_prob = 0.01  # Probability of salt noise
pepper_prob = 0.01  # Probability of pepper noise
noisy_images = [add_salt_pepper_noise(image, salt_prob, pepper_prob) for image in sample_images]

# Apply median filter to each noisy image
filtered_images = [median_filter(image) for image in noisy_images]

# Display original, noisy, and filtered images
plt.figure(figsize=(15, 5))
for i in range(len(sample_images)):
    plt.subplot(3, len(sample_images), i + 1)
    plt.imshow(sample_images[i], cmap='gray')
    plt.title('Original')
    plt.axis('off')

    plt.subplot(3, len(sample_images), len(sample_images) + i + 1)
    plt.imshow(noisy_images[i], cmap='gray')
    plt.title('Noisy')
    plt.axis('off')

    plt.subplot(3, len(sample_images), 2 * len(sample_images) + i + 1)
    plt.imshow(filtered_images[i], cmap='gray')
    plt.title('Filtered')
    plt.axis('off')
```