GROUP 21 - APPLICATION INVOLVING EDGE ENHANCEMENT

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What is an Edge?

Not this edge

1. In image processing, an edge is a boundary where there's a **significant change in intensity or color**, typically marking the borders between different objects or regions in an image.
2. These intensity changes represent shifts from one pixel value to another, helping distinguish objects from their background.
3. Edges are essential features in images, especially in GIS, as they help define the shapes and positions of geographical elements like roads, rivers, and buildings.

Edge Enhancement?

Edge enhancement is an image processing technique designed to make the boundaries within an image more distinct.

It works by emphasizing areas in an image where intensity changes sharply, highlighting the edges of objects or features.

For GIS, this allows for improved accuracy in mapping, classification, and change detection tasks by making key boundaries more visible, even in complex or noisy images

Original image

Image with enhanced edges

Applications of Edge Enhancement

Edge enhancement is an image processing technique designed to make the boundaries within an image more distinct. It works by emphasizing areas in an image where intensity changes sharply, highlighting the edges of objects or features. In edge enhancement, algorithms detect edges by calculating gradients or changes in pixel intensity. Common methods include convolution filters like Sobel, Prewitt, and Canny filters, each designed to emphasize contrast at edges. Enhanced images often appear sharper and more detailed, making it easier to interpret and analyze specific features. For GIS, this allows for improved accuracy in mapping, classification, and change detection tasks by making key boundaries more visible, even in complex or noisy images

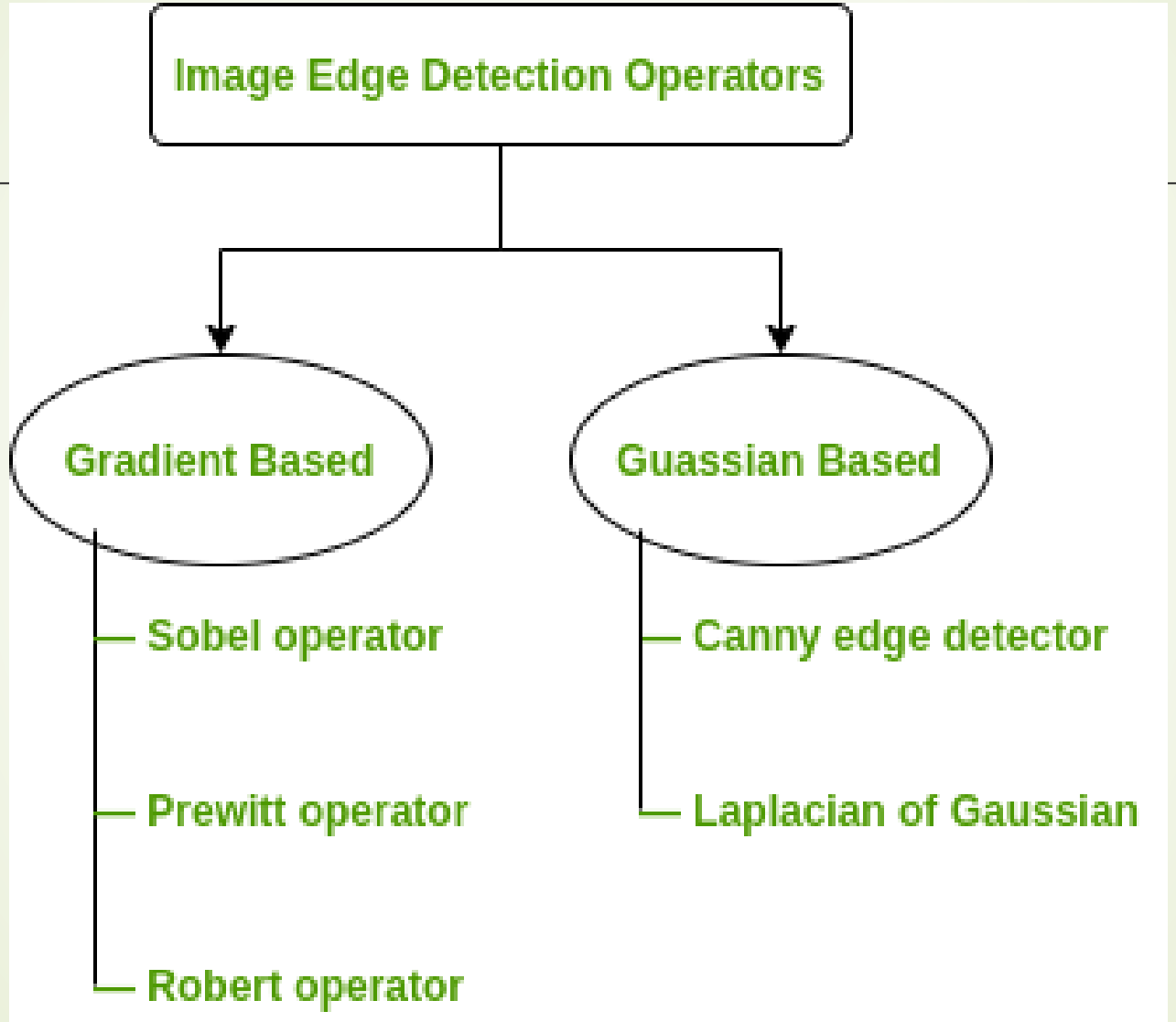


Image Edge Detection Operators
Gradient Based
Guassian Based
Sobel operator
Prewitt operator
Robert operator
Canny edge detector
Laplacian of Gaussian

Different Edge Enhancement Techniques

Commonly used techniques are:

1- Sobel Filter

- The sobel is one of the most commonly used edge detectors. It is based on convolving the image with a small, separable, and integer valued filter in horizontal and vertical direction. Sobel edge enhancement filter has the advantage of providing differentiating (which gives the edge response) and smoothing (which reduces noise) concurrently.
- The Sobel filter emphasizes horizontal and vertical edges in an image by computing gradients along the x and y axes.
- It is especially useful for highlighting edges in well-lit images with minimal noise.
- The result is an image with pronounced boundaries where intensity changes occur, making it ideal for simple, high-contrast images.

$$G_x = \begin{bmatrix} 1 & 0 & -1 \\ 2 & 0 & -2 \\ 1 & 0 & -1 \end{bmatrix} \quad G_y = \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}$$

Sobel Mask

Different Edge Enhancement Techniques

2 - Prewitt Filter

- Prewitt operator is similar to the Sobel operator and is used for detecting vertical and horizontal edges in images. However, unlike the Sobel, this operator does not place any emphasis on the pixels that are closer to the center of the mask.
- Similar to the Sobel filter, the Prewitt filter also calculates gradients to detect horizontal and vertical edges.
- It is often used for basic edge detection and performs well in low-noise environments.
- Compared to Sobel, it's slightly less sensitive to noise, which can be advantageous in some cases.

$$G_x = \begin{bmatrix} 1 & 0 & -1 \\ 1 & 0 & -1 \\ 1 & 0 & -1 \end{bmatrix} \qquad G_y = \begin{bmatrix} 1 & 1 & 1 \\ 0 & 0 & 0 \\ -1 & -1 & -1 \end{bmatrix}$$

Prewitt Mask

Different Edge Enhancement Techniques

3- Laplacian of Gaussian (LoG)

- The LoG filter combines Gaussian smoothing with the Laplacian operator. First, it smooths the image to reduce noise and then uses the Laplacian to detect edges.
- This method captures edges more precisely, even in noisy images, making it useful for applications where noise reduction is critical before edge enhancement.

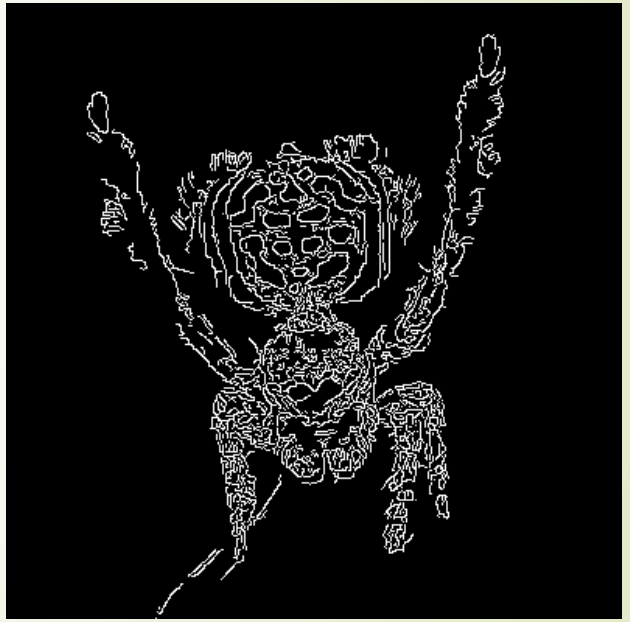
0	−1	0
−1	4	−1
0	−1	0

−1	−1	−1
−1	8	−1
−1	−1	−1

Different Edge Enhancement Techniques

4- Canny Edge Detection

- The Canny method is a multi-step algorithm designed for robust edge detection. It involves:
  - Smoothing with a Gaussian filter,
  - Computing gradients,
  - Applying non-maximum suppression (to thin edges),
  - And double thresholding to connect edges.
- Canny is effective for detecting a wide range of edges, even in noisy images, and is considered a standard for high-accuracy edge detection.



Different Edge Enhancement Techniques

5. Unsharp Masking

- Unsharp masking is a technique that enhances edges by subtracting a blurred version of the image from the original.
- It’s commonly used in applications requiring fine-tuned control over enhancement intensity.
- This technique is widely applied in photo editing but can be adapted for GIS imagery to highlight subtle edges without overly distorting the image.

Application involving Edge Enhancement

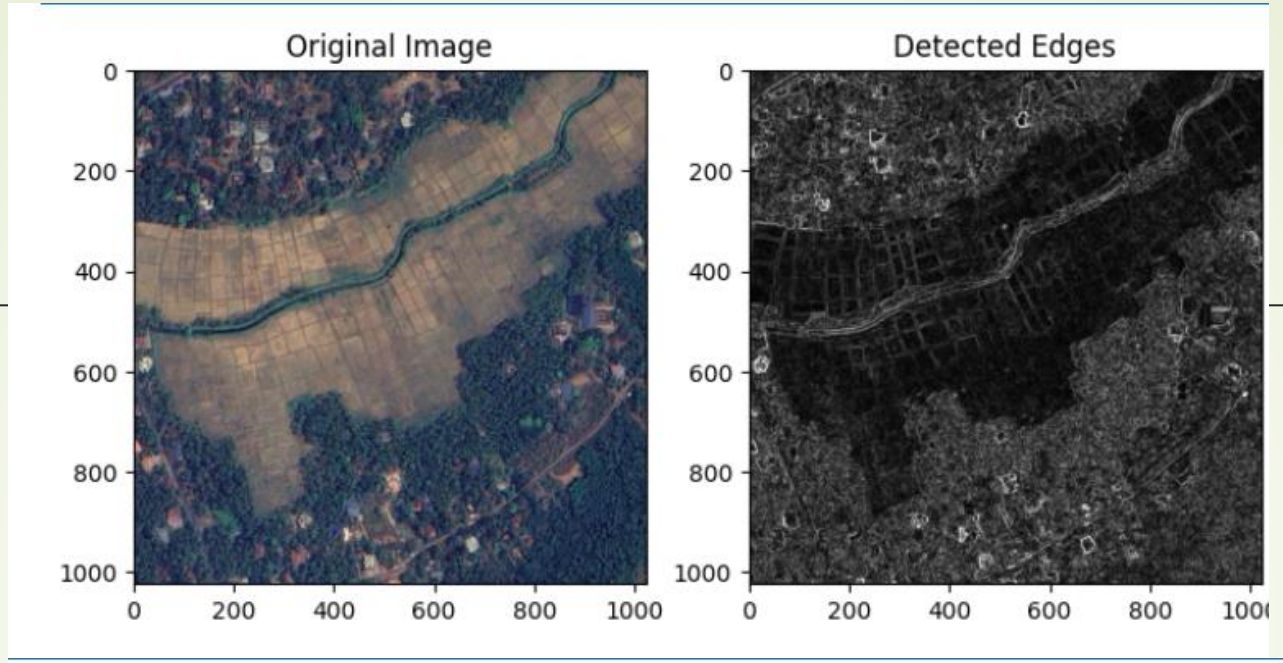
1- Highlighting Boundaries Between Land and Water

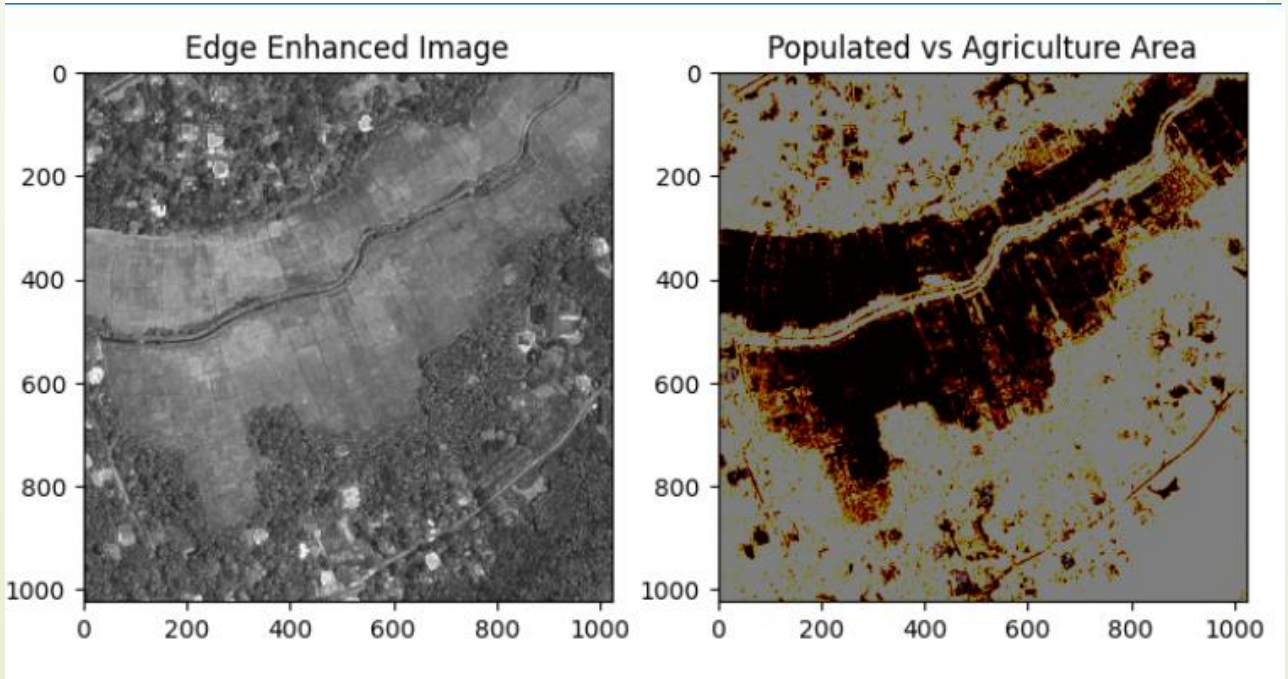
- **Edge enhancement** intensifies the contrast at the boundary between water and land, making it easier to distinguish water bodies from surrounding areas. This is particularly valuable when analyzing areas with complex shoreline geometries, such as rivers, lakes, or small ponds, where natural borders might otherwise blend into adjacent land features.

Application involving Edge Enhancement

2- Distinguishing b/w agricultural areas from populated regions

Edge enhancement helps distinguish agricultural from populated areas in satellite images by clarifying boundaries. Agricultural zones appear as large, regular patches, while populated areas have irregular, dense edges. Techniques like Canny and Sobel filters make boundaries more distinct, aiding automated segmentation and land classification. Using multi-spectral bands with edge enhancement further highlights vegetation versus urban structures. This approach also supports monitoring land use changes, like urban expansion into farmland, making it valuable for urban planning and environmental management.


Original Image
Detected Edges
0
200
400
600
800
1000

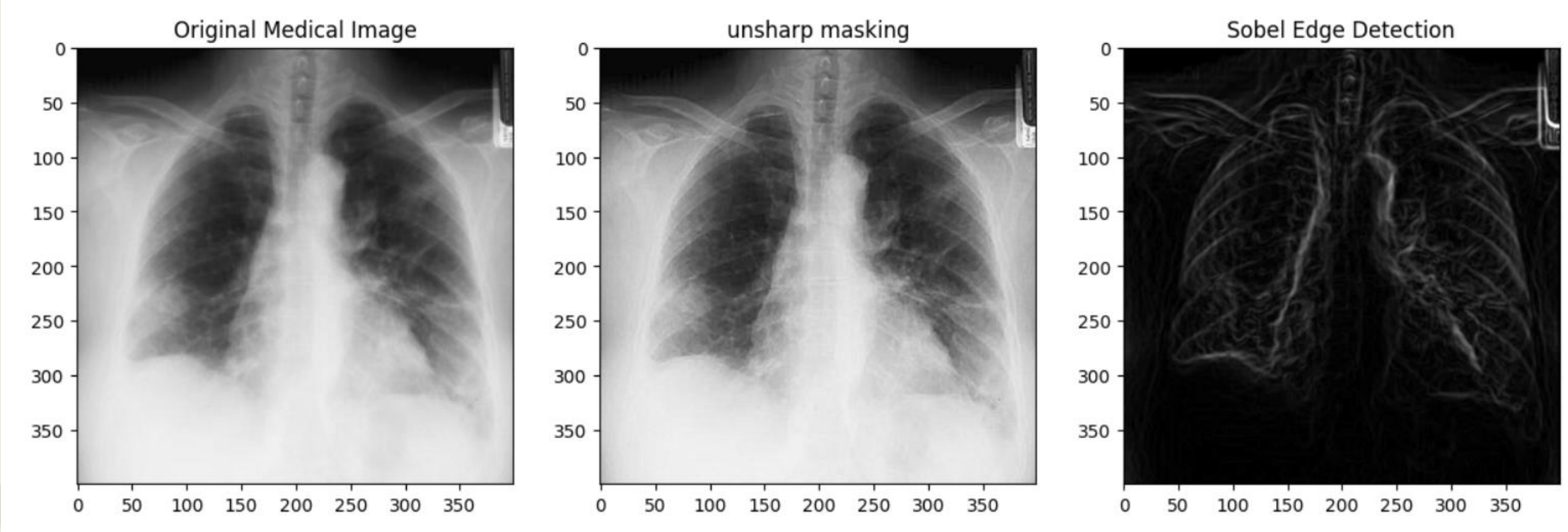

Edge Enhanced Image
Populated vs Agriculture Area
0
200
400
600
800
1000

Different Edge Enhancement Techniques

Medical Images

1- X-ray Imaging

- **Bone and Tissue Boundaries**: Edge enhancement increases contrast, clarifying distinctions between bones and soft tissues, aiding in fracture detection and orthopedic assessments.
- **Microfractures and Lesions**: Tiny fractures or early-stage damage become clearer, enabling early detection of conditions like osteoporosis.
- **Lung Conditions**: Edge enhancement highlights slight density differences, helping detect abnormalities like infections or nodules.



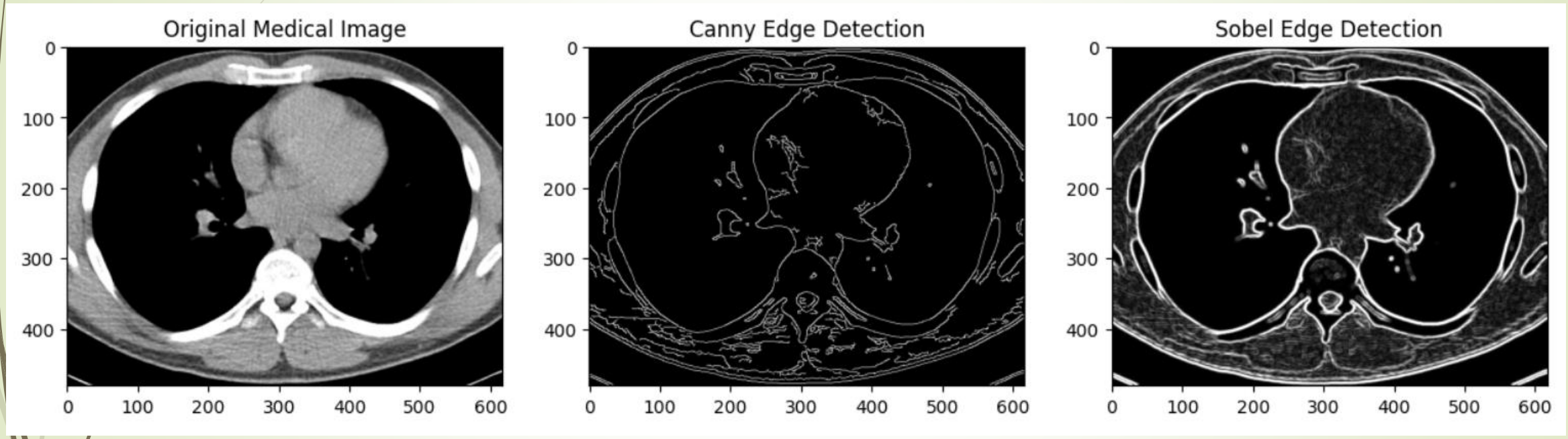
X RAY Edge Enhancement

Different Edge Enhancement Techniques

Medical Images

2- MRI Imaging

- **Soft Tissue Clarity**: Enhancing edges reveals finer details in tissues like cartilage and ligaments, aiding in diagnosing injuries.
- **Tumor Boundaries**: Precise edge enhancement helps define tumors for treatment planning, particularly in complex areas like the brain.
- **Complex Anatomy**: In regions like the spine or brain, edge enhancement differentiates between dense structures, supporting diagnoses for neurological conditions.



Brain MRI Edge Enhancement

code for the project

THANK YOU