Modified operators for digital image enhancement of radiograph films digitized by low cost flatbed

Aim of the work

- The aim of this work is to develop modified sharpening spatial operators which can be used alone or in addition to the existent smoothing spatial operators to enhance digitized images of radiographic films captured using low cost flatbed scanner.

Content

- Introduction
- Digital image processing (DIP)
- Modified operators
- Materials
- Method
- Results
- Conclusions
- Future work

Introduction

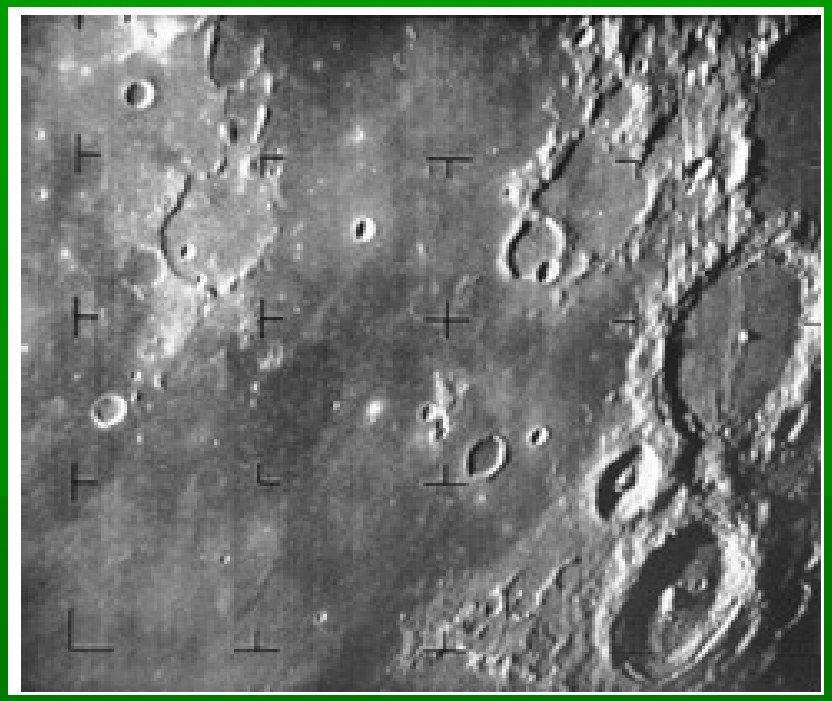
- Image is two dimensional function $f(x, y)$ when x and y are the spatial coordinates also they can represent the coordinates of the pixels which are the finite elements of the picture

- The mathematical model of the digital image is matrix $(M \times N)$ in the following form:

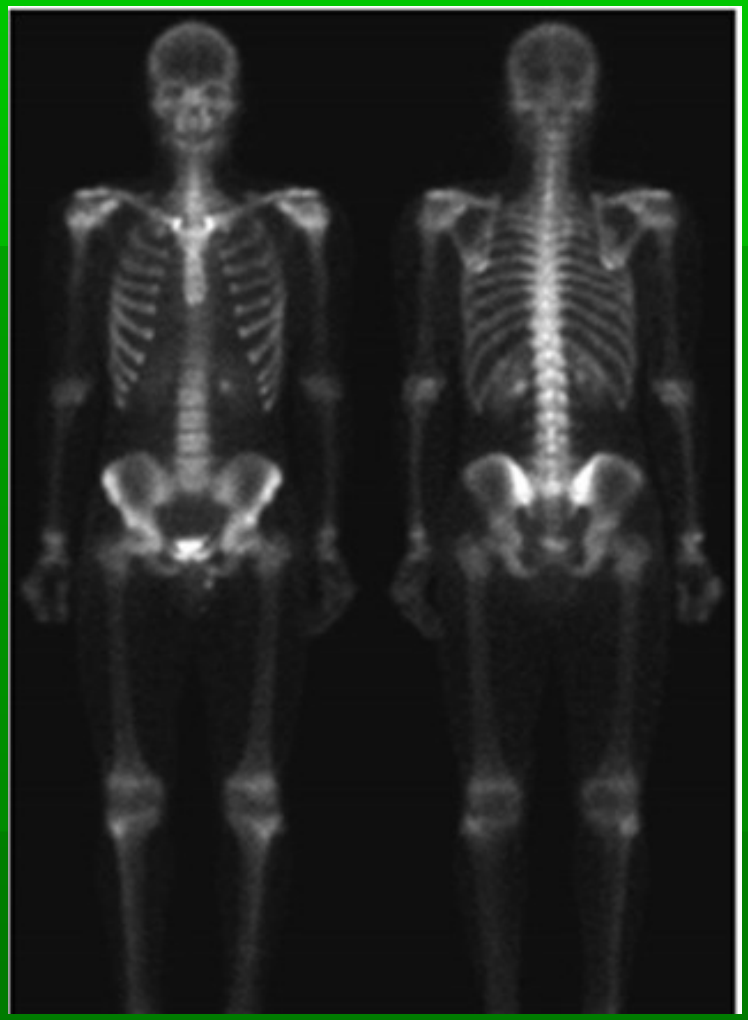
$$f(x,y) = \begin{bmatrix} f(0,0) & f(0,1)..... & f(0,N-1) \\ f(1,0) & f(1,1)..... & f(1,N-1) \\ . & . & . \\ . & . & . \\ . & . & . \\ . & . & . \\ . & . & . \\ f(M-1,0) & f(M-1,1)..... & f(M-1,N-1) \end{bmatrix}$$

- The first application of digital images (DI) was in the news paper industry when pictures were first sent by submarine cable between London and New York in 1920s.

- The beginning of (DIP) started with the race of space discoveries.



- DIP techniques began in the lattes 1960s and early 1970s to be used in medical imaging.



Digital image processing

Applications of DIP

- Digital image enhancement
- Image restoration
- Color image processing
- Morphological process
- Image matching
- Edge detection

Components of DIP systems

- Sensor
- Digitizer
- Computer
- Software
- Memory

Types of image digitizers

- Flatbed scanner
- Sheet-fed scanner
- Drum scanner
- Digital camera
- Film scanner

$16,495.00

$10,445.00

$48.97

Digital image enhancement

- Frequency domain techniques
- Spatial domain techniques

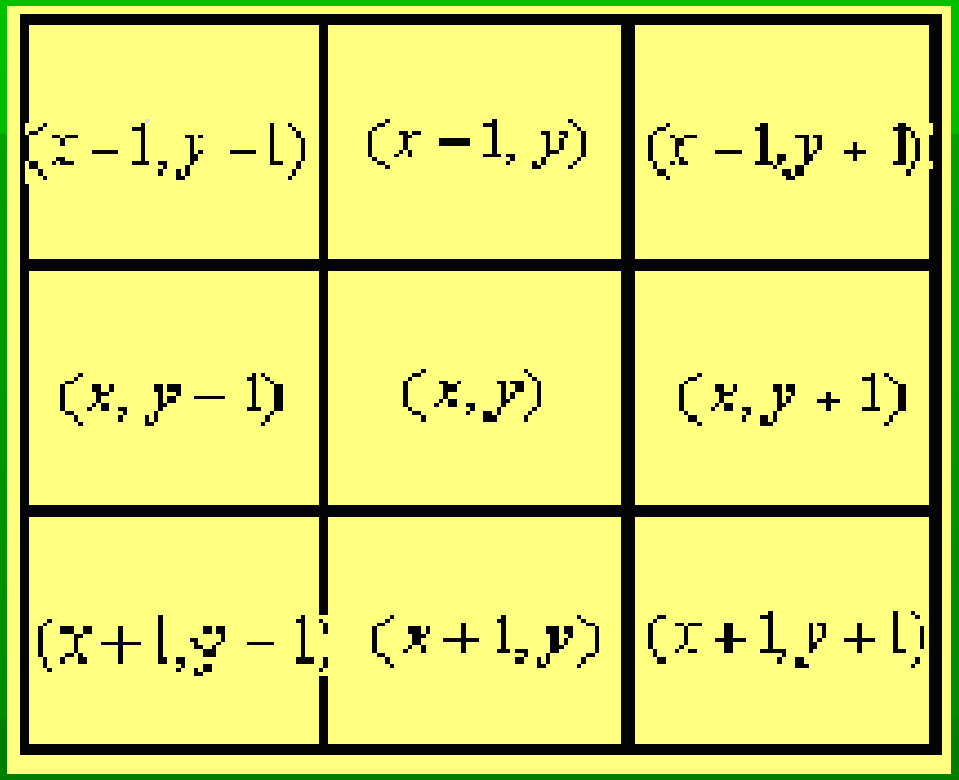
Spatial domain techniques

- One pixel processing
- Multi pixels processing

One pixel processing

- *Simple intensity processing*
  - Image negatives
  - Contrast stretching
  - Compression of the dynamic rang
  - Gray level slicing
- *Histogram processing*
  - Histogram equalization
  - Histogram specification

Multi pixels processing



The 8-neighbors of pixel $P(x, y)$

Smoothing spatial operators

- the goal is to increase the blur of the image to remove small details from an image and bridging of small gaps or smoothing the false contours.
- There are manly two mathematical concepts used in smoothing process
  - Averaging
  - Mediating (nonlinear)

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

1	1	1
1	1	1
1	1	1

A: Mask of averaging filter with equal weight for all neighbors

$\frac{1}{16} \times$

1	2	1
2	4	2
1	2	1

B: weighted averaging mask

Sharpening spatial operators

- Sharpening is the opposite process of smoothing which used to highlight fine details of an image

- Mathematically sharpening process can be modeled as a differentiation operation. that sharpening depends on increasing the difference in gray level of neighborhood pixels

Second derivative operator

- It was founded that the simplest isotropic second derivative operator is the Laplacian which have the following form

$$\nabla^2 f(x,y) = \frac{\partial^2 f(x,y)}{\partial x^2} + \frac{\partial^2 f(x,y)}{\partial y^2}$$

So it can be written as the following

$$\nabla^2 f(x,y) = [f(x+1,y) + f(x-1,y) + f(x,y+1) + f(x,x-1)] - 4f(x,y)$$

A

0	1	0
1	-4	1
0	1	0

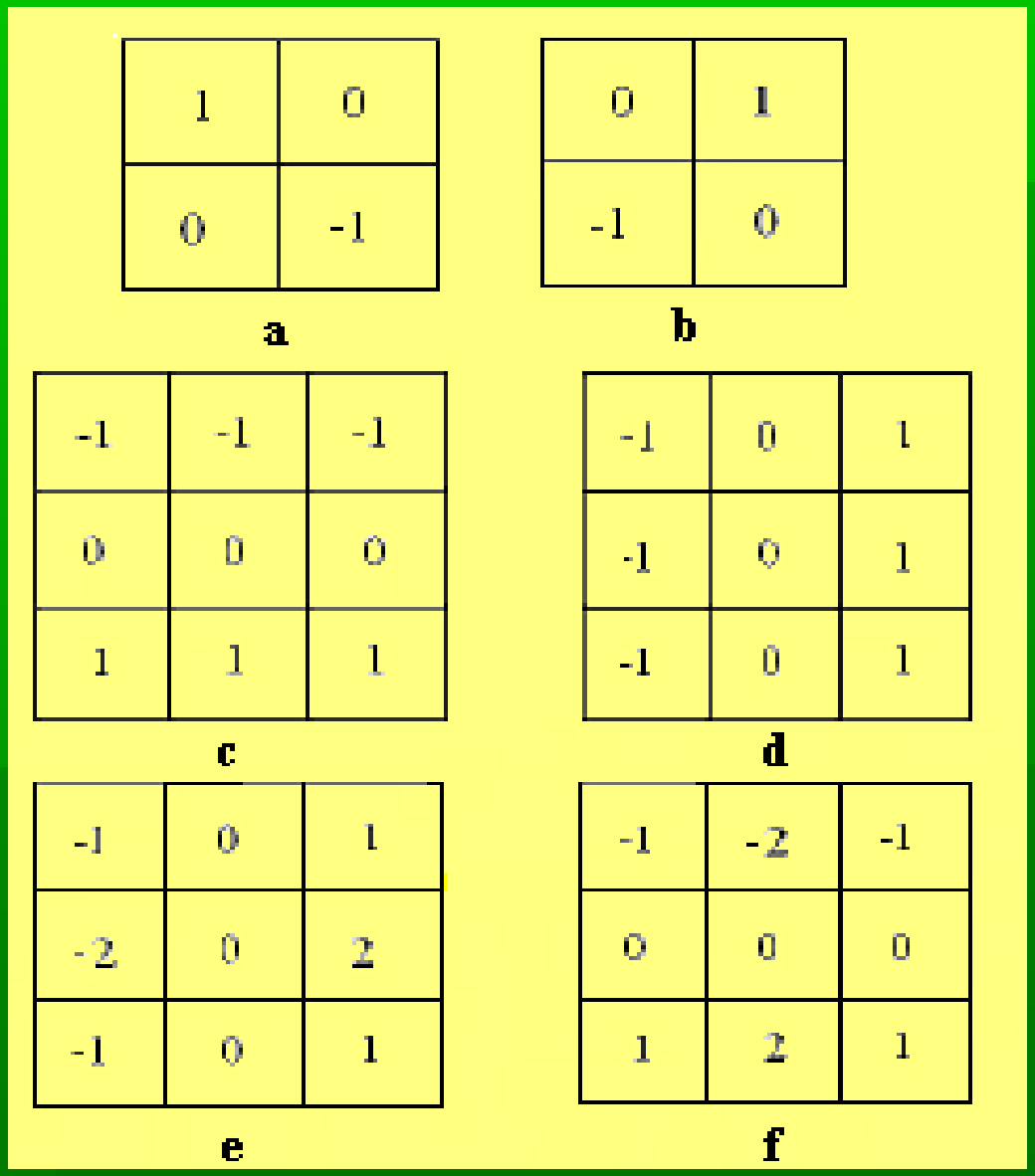
Laplacian mask to sharpen the horizontal and vertical lines

B

1	1	1
1	-8	1
1	1	1

Laplacian mask to sharpen the oblique lines in addition to the horizontal and vertical ones

First derivative operators



1	0
0	-1

a

0	1
-1	0

b

-1	-1	-1
0	0	0
1	1	1

c

-1	0	1
-1	0	1
-1	0	1

d

-1	0	1
-2	0	2
-1	0	1

e

-1	-2	-1
0	0	0
1	2	1

f

Masks for first order derivative sharpening

a: horizontal Roberts,

b: vertical Roberts,

c: horizontal Prewitt,

d: vertical Prewitt,

e: horizontal Sobel,

f: vertical Sobel

Nonlinear sharpening

- The following equation represents one of the used equations for nonlinear sharpening

$$P(x,y) = \frac{P(x-1,y-1)+P(x,y-1)+P(x+1,y-1)}{3} + \frac{P(x-1,y+1)+P(x,y+1)+P(x+1,y+1)}{3} + P(x-1,y)+P(x+1,y)-P(x,y)$$

The modified operators

- Increase the intensity
- Sharpening
- Smoothing (optional)

a

1	1	1
1	-3	1
1	1	1

b

1	1	1
1	-4	1
1	1	1

c

1	1	1
1	-5	1
1	1	1

d

1	1	1
1	-6	1
1	1	1

e

1	1	1
1	-7	1
1	1	1

Materials

- Radiograph films

Sample	Quality
Pelvic	poor
Chest	acceptable
Knee	proper

Pelvic

Chest

Knee

- Digitizer

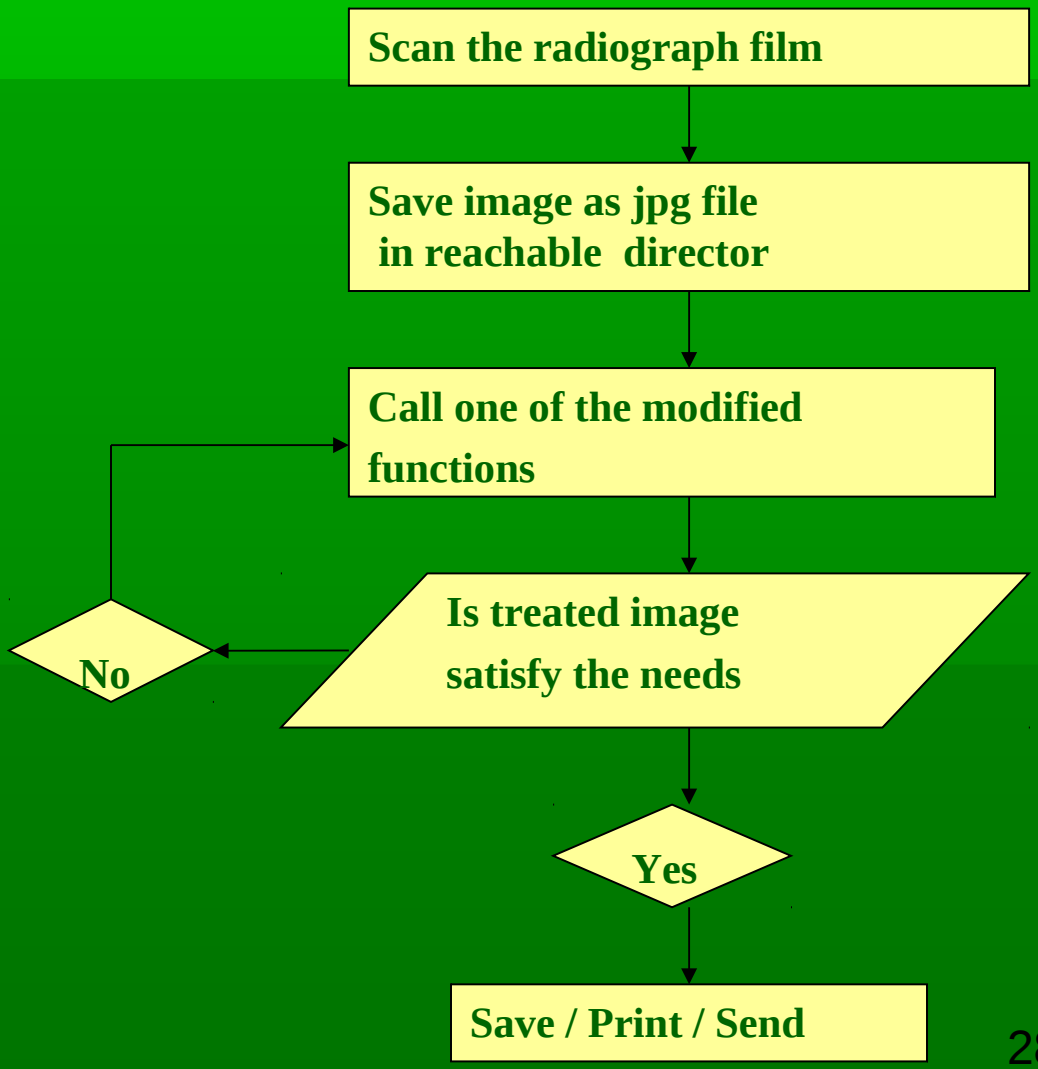
Scanner type	Flatbed scanner
Optical resolution	1200 dpi
Max resolution	1200 x 600 dpi
Form factor	desktop
Max size of media	216 x 297 mm

- Computer

Processor	Intel Pentium III
Speed	701 MHz
RAM	256 Mb

Method

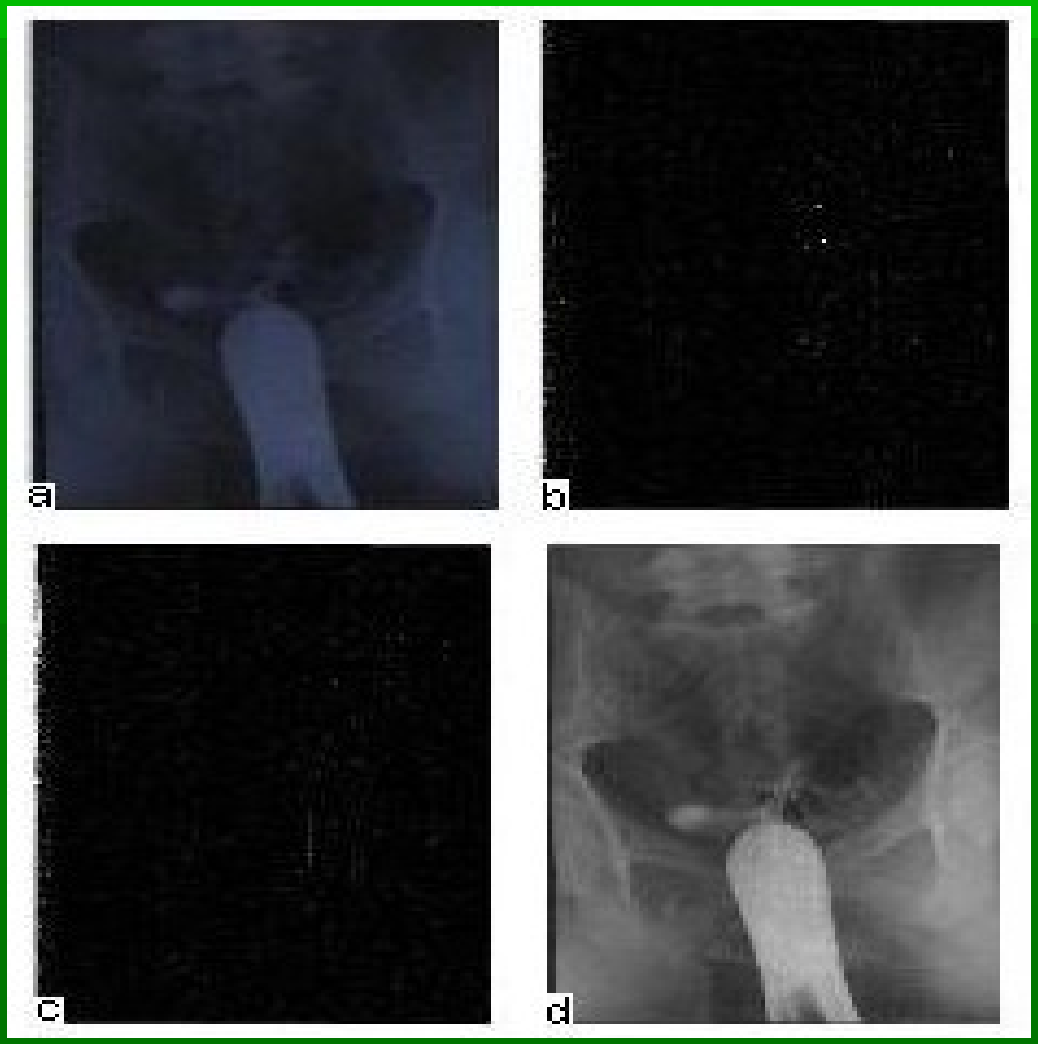
- Flow chart of the program



Results

Second derivative operators

Original

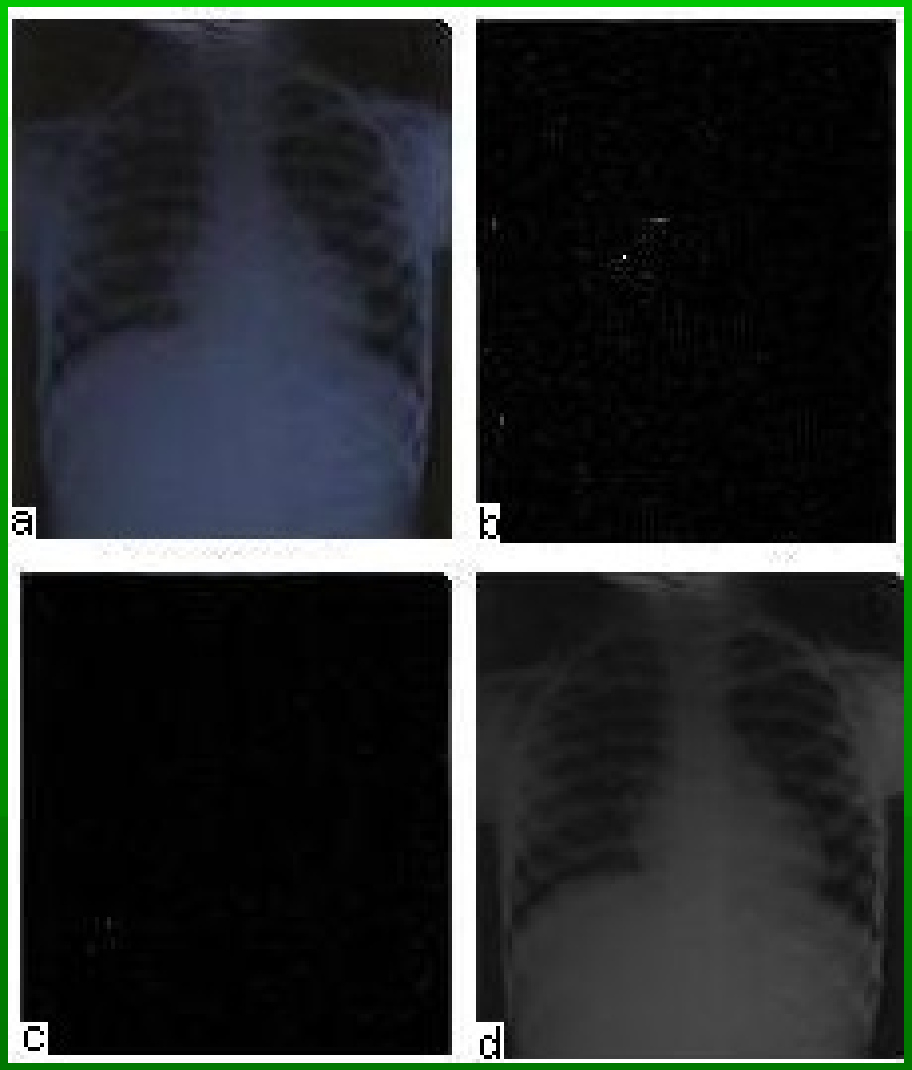


Linear sharpening A

Linear sharpening B

Nonlinear sharpening

Original



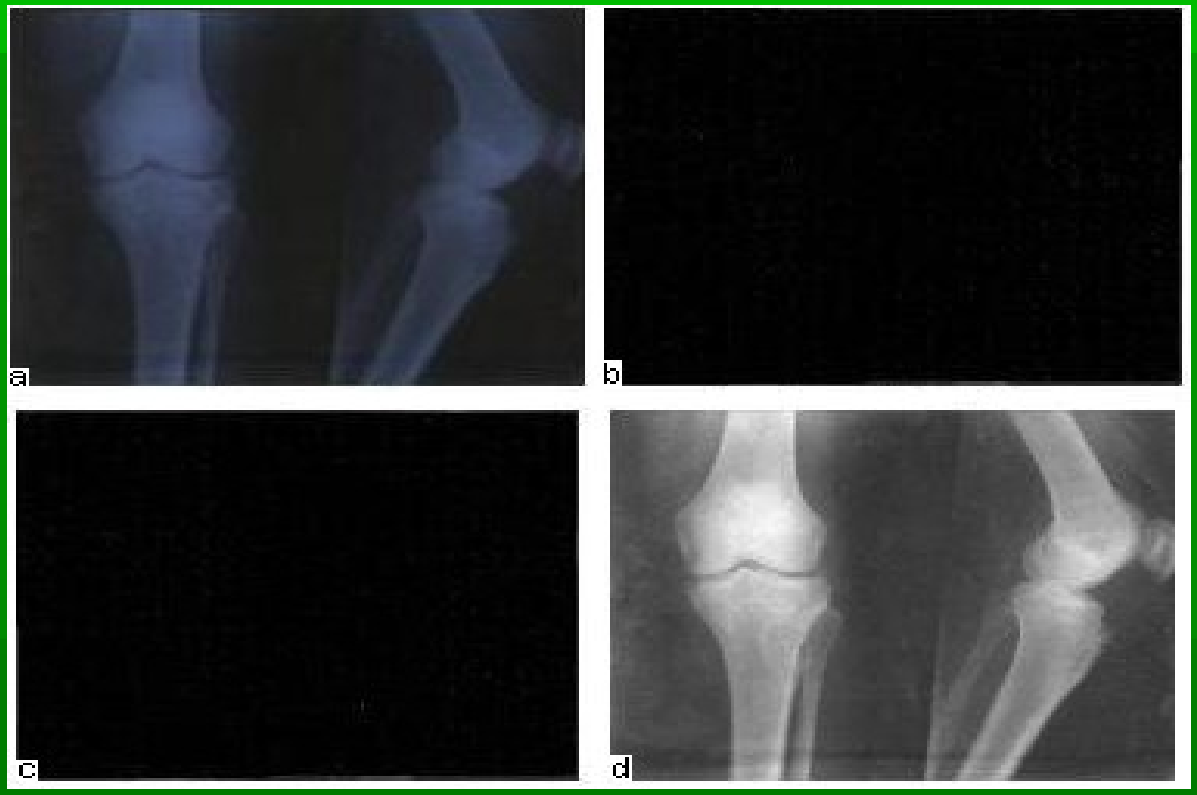
Linear sharpening A

Linear sharpening B

Nonlinear sharpening

Original

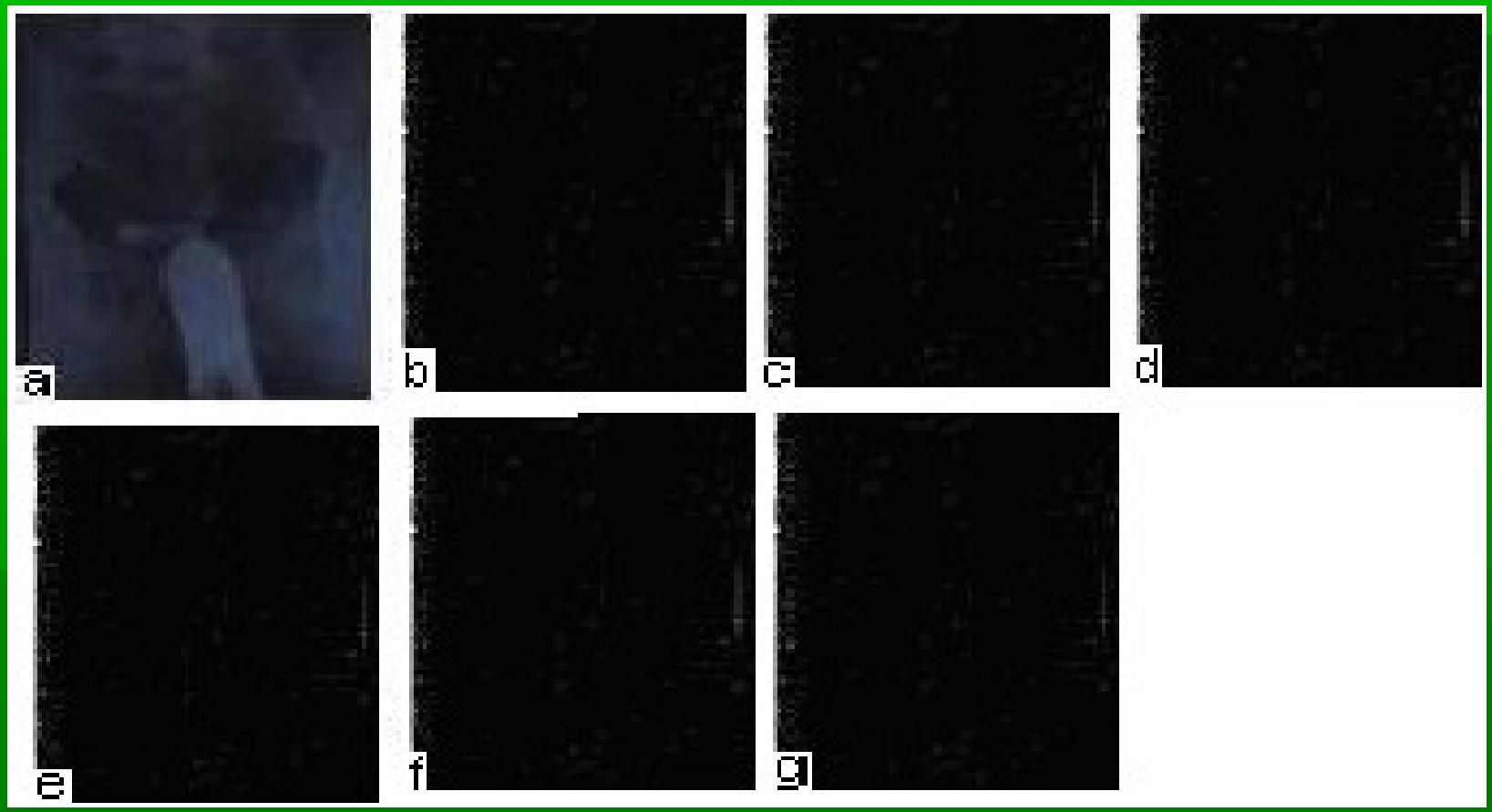
Linear sharpening A



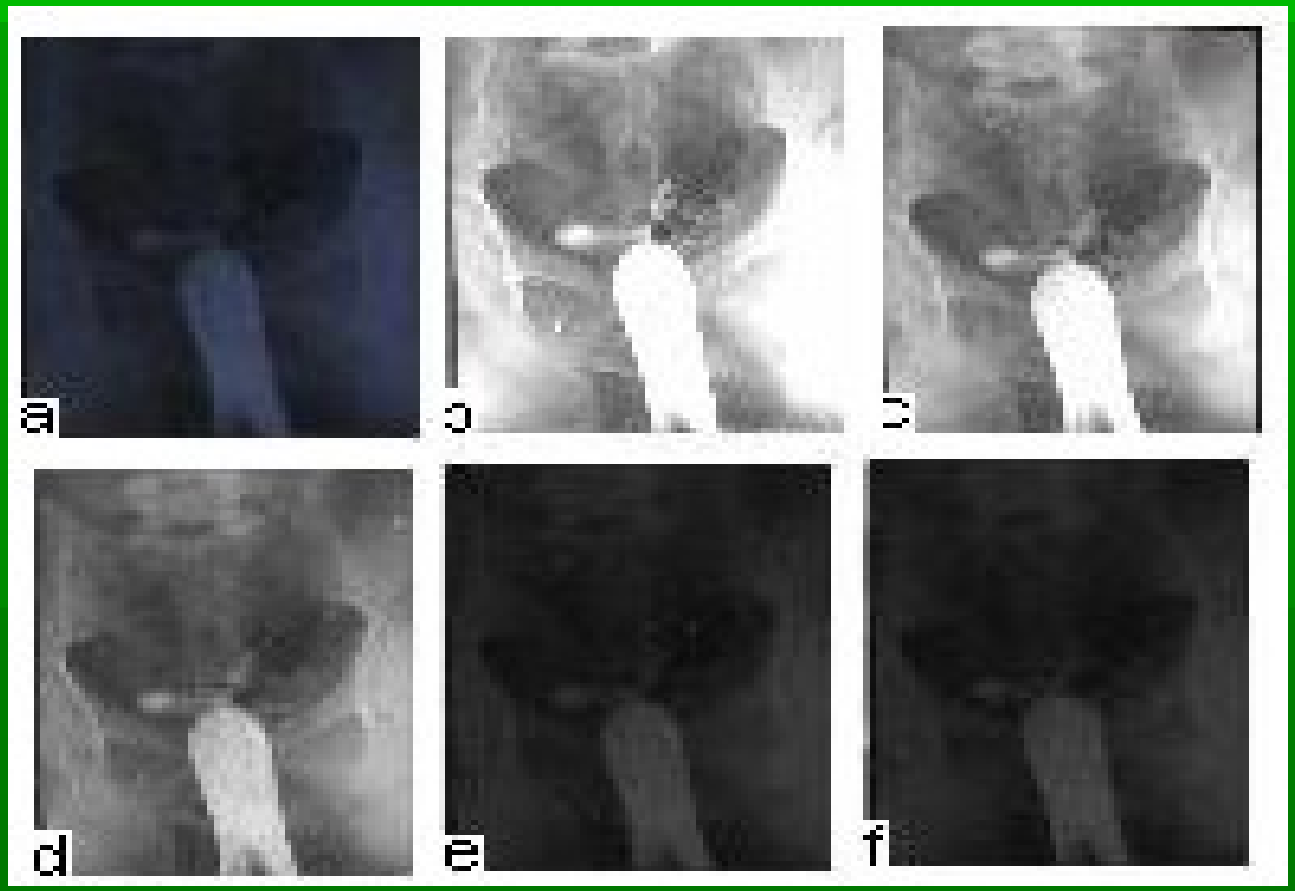
Linear sharpening B

Nonlinear sharpening

First divertive operators



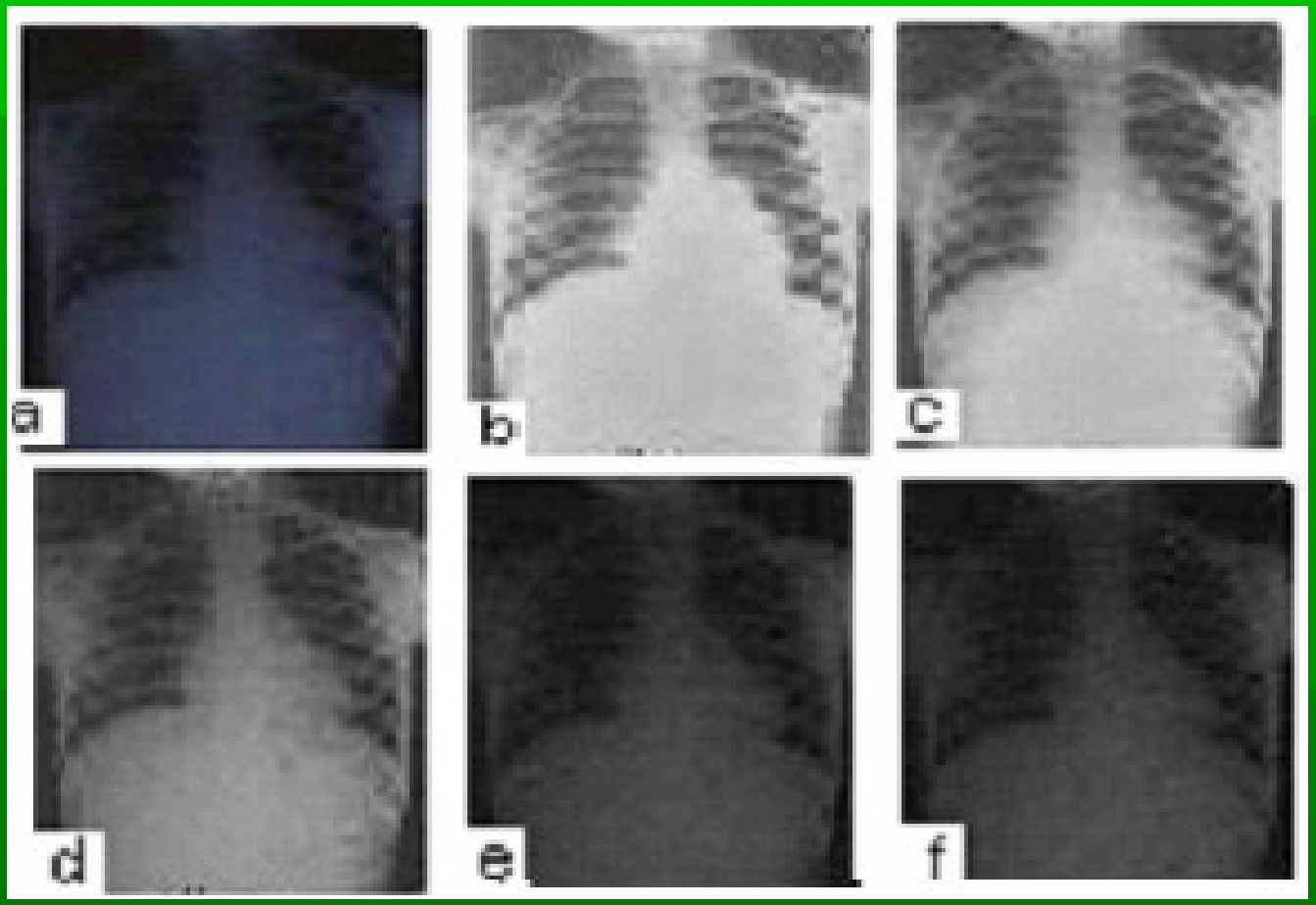
Modified operators



Original

Sharpen3

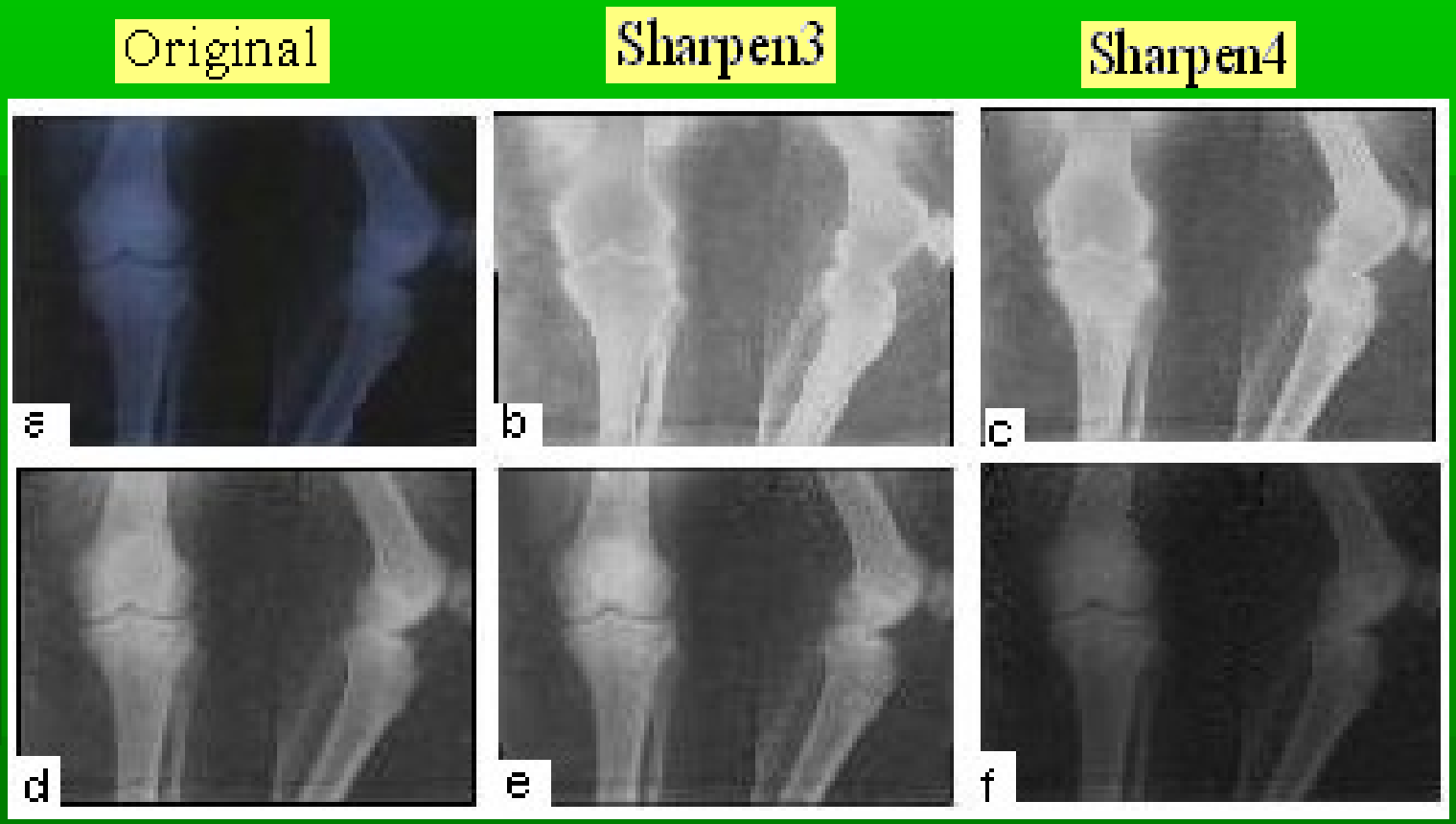
Sharpen4



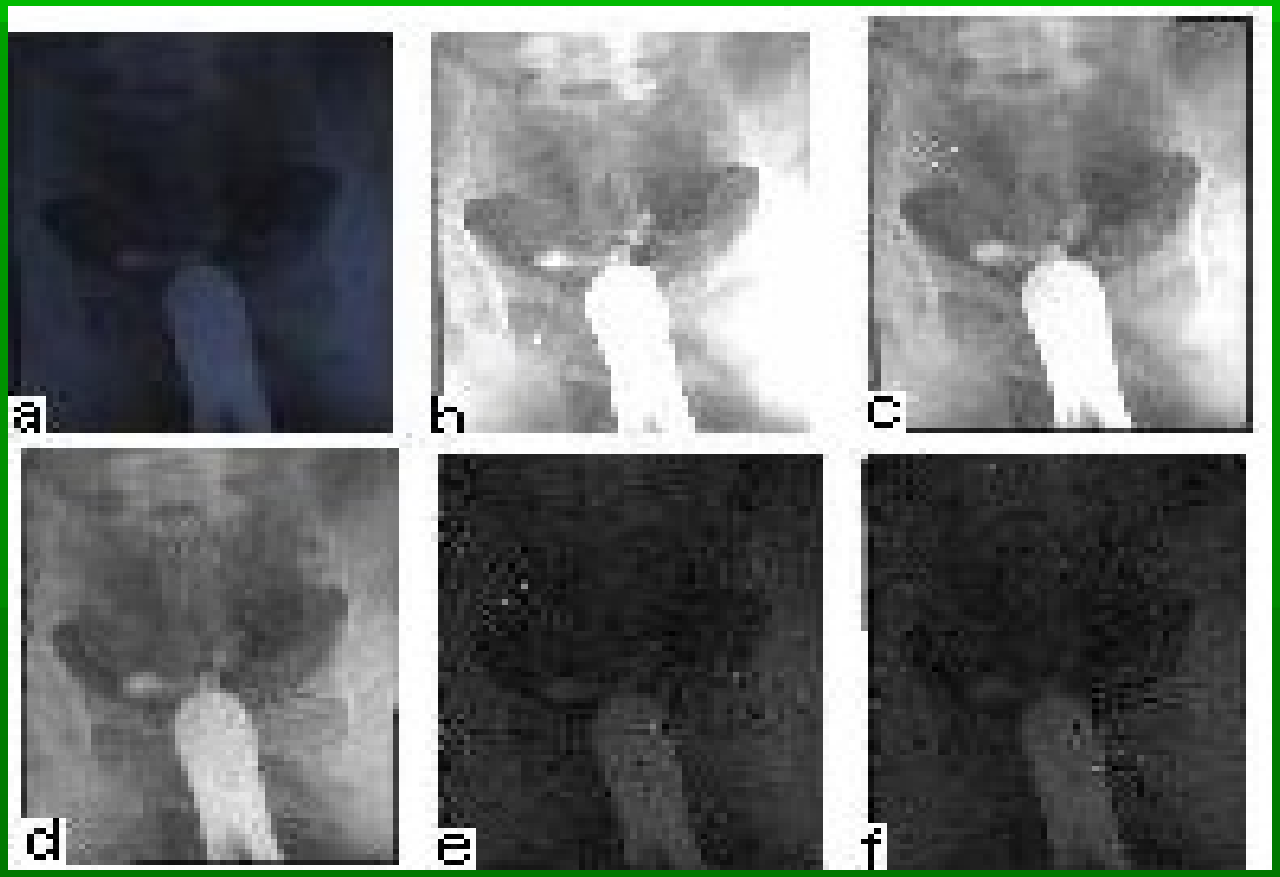
Sharpen5

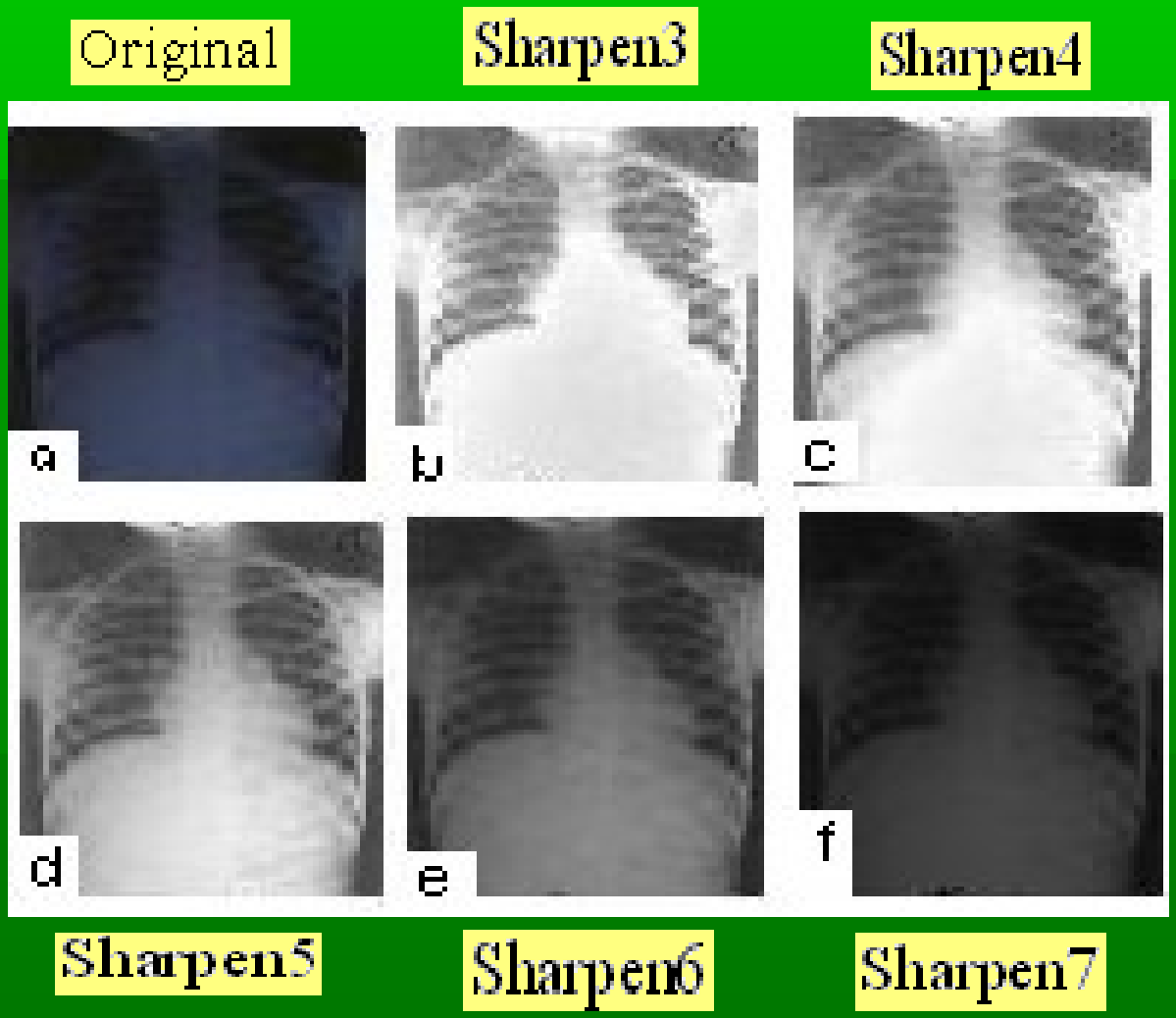
Sharpen6

Sharpen7


Original
Sharpen3
Sharpen4
a
b
c
d
e
f
Sharpen5
Sharpen6
Sharpen7

Modified operators plus smoothing




Original
Sharpen3
Sharpen4
a
b
c
d
e
f
Sharpen5
Sharpen6
Sharpen7

Original

Sharpen3

Sharpen4

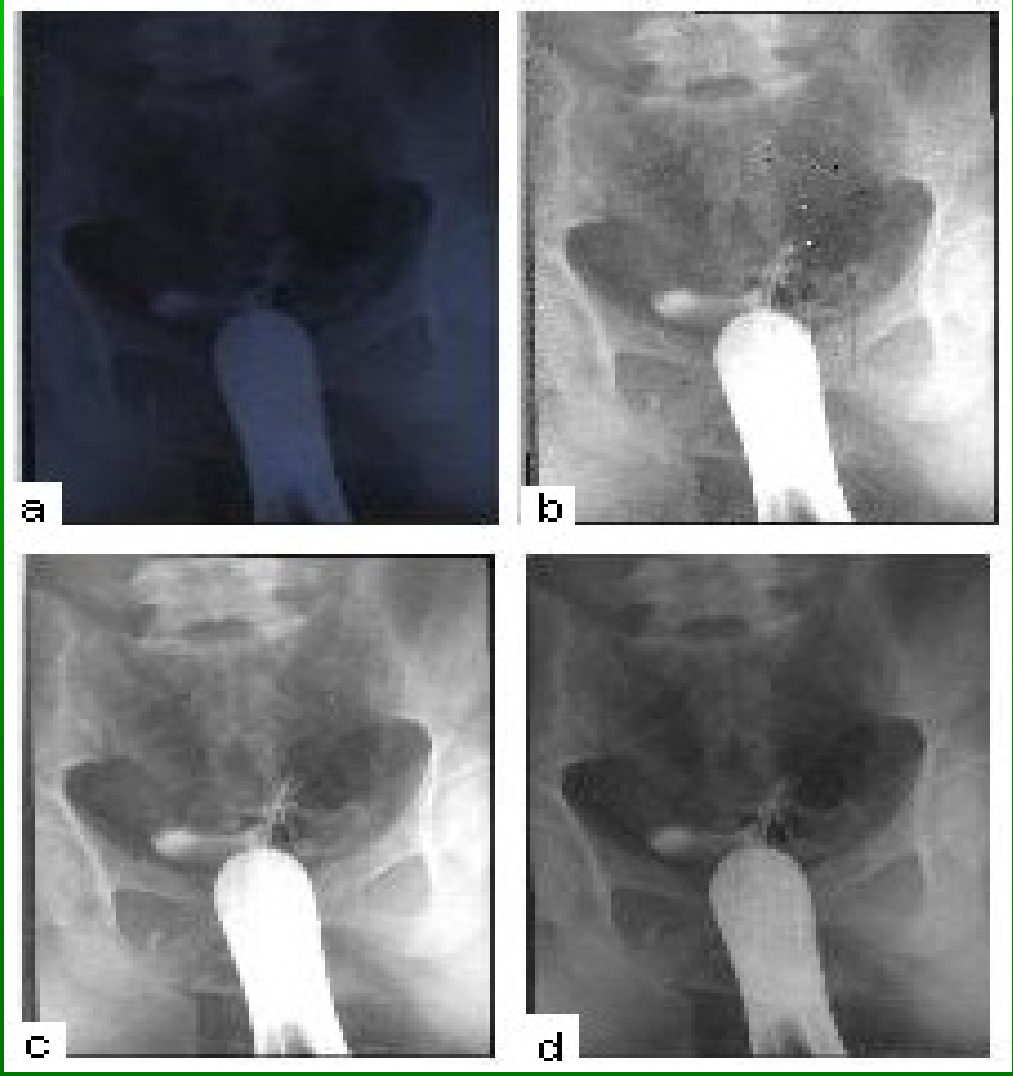
Sharpen5

Sharpen6

Sharpen7

Comparison

Original



Sharpen 4

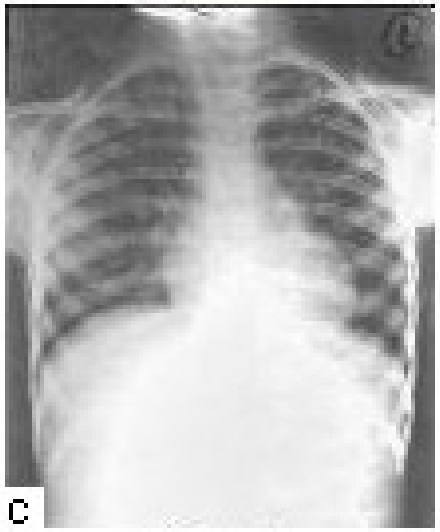
Sharpen 4 plus smoothing

Nonlinear sharpening

Original

Sharpen 4

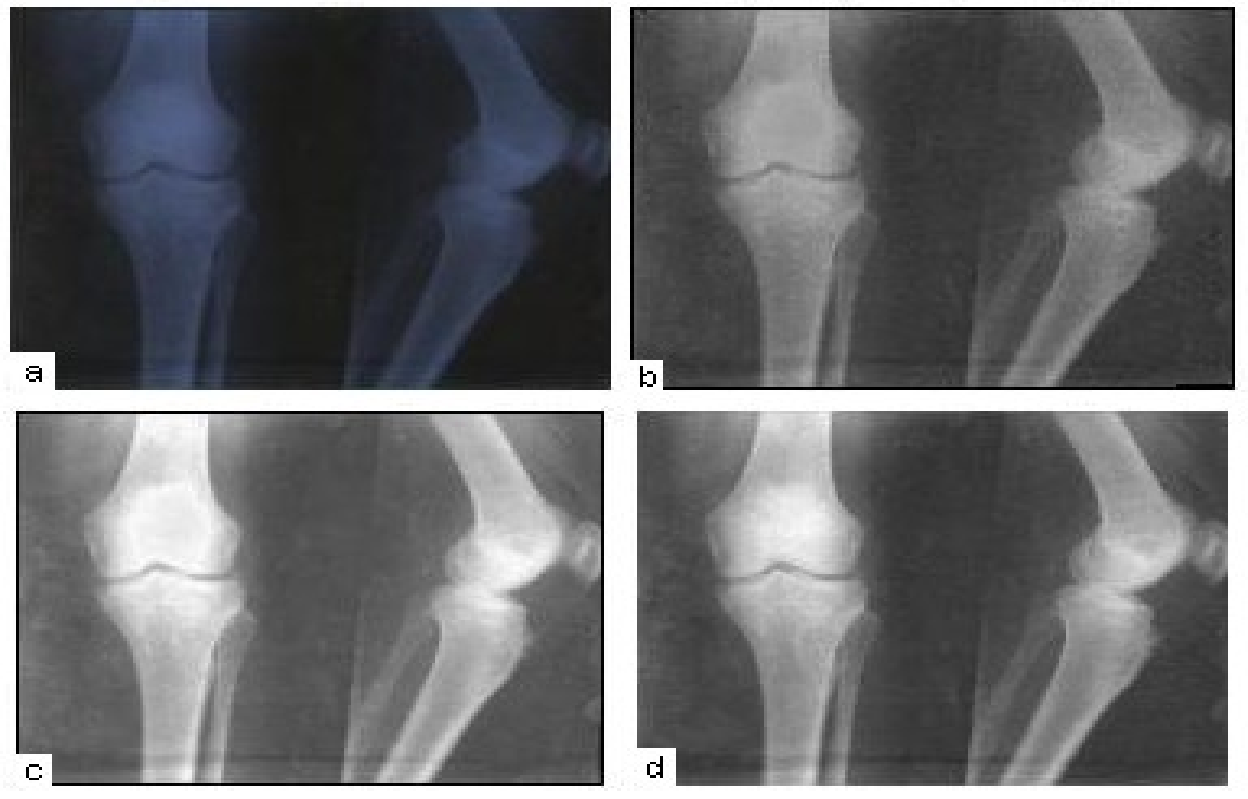
Sharpen 4 plus smoothing



Nonlinear sharpening

Original

Sharpen 4



Sharpen 4 plus smoothing

Nonlinear sharpening

Conclusion

- The modified operators achieve acceptable enhancement of the images.
- Centers or departments of radiology can get the benefits of
- Digital image processing
- Digital image transmitting
- Digital archiving
- Teleradiology, Telemedicine

with considerable costs of resources.

Future works

- In the real time application
- Dealing with color images

Thank you