DETECTION AND SEGMENTATION OF LUNG CANCER ON CT IMAGES BY USING FRACTIONAL CALCULUS

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Abstract- Now a day's Lung Cancer providing to be a catastrophic Threat to the Mankind and is main cause of Human deaths among other cancer related casualties. Early detection of lung cancer is the most challenging problem in medical research. This is due to abnormal formation of cells which may be sometime overlap. The presence of solitary pulmonary nodules in human lungs are in the form of malignant determines the gravity of lung ailments. Image processing which is growing research area has been playing a central role in the detection of lung cancer images. Among many imaging modalities CT leads to higher resolution. In this project an automatic lung nodule detection system is proposed. Many segmentation methods have been used to detect the malignant cells in lung affected CT images. The edges of segmented object are not clearly identified using conventional segmentation methods. Hence the detection and extraction of lung tumor is not accurate. The proposed system is fractional calculus based segmentation through which the segmentation and edge detection process become adequate to extract lung tumor in CT images.

Index Terms—Lung tumor, CT image, Sobel edge, Canny edge, Fractional calculus.

I. INTRODUCTION

Image edge analysis constitutes a set of mathematical methods which aim at identifying points in a digital image at which the image brightness changes sharply (point of discontinuities). The organization of these points into a set of curved line segments then becomes the edge (1). With no doubt, detecting these points and subsequently constructing an edge map is one of the most common and fundamental operations in image processing and analysis since it is consistent with the human perception and serves as the first step in image understanding and interpretation. They provide useful structural information, which can be used for feature extraction, object identification and region segmentation. This information, by common practice, is extracted by developing a convolution mask mostly known as the gradient operator which is a relatively smaller two dimensional array where each pixel value of the original image is modified according to the value of the neighborhood around the pixel of interest (POI). However, there are other forms, such as the segmentation-and transform-based operators, which could also be used for edge. The definitions of particular operators in any of these three categories have their own pros and cons(2). Although several studies have been done to improve these methods for edge detection, they still produce edges with some compromise in accuracy, completeness, complexity, connectedness, and smoothness. Recent study by Guo and Lai confirmed how gradient operators resist just low-level noises but tend to mistakenly detect fake edges in the presence of excessive noise or artifacts.

In an attempt to resolve some of these issues other operators mostly based on fractional calculus with improved characteristics over the classical methods like Canny and Prewitt have been proposed. In particular the fractional based operators have been used in image quality enhancement, image texture enhancement, image denoising, and image edge analysis. Among such operators, which are a generalization of the concept of an integer order derivative to real order and the *n*-fold integral operator, are the Caputo, Erdelyi-Kober,Srivastava Owa, and Weyl-Riesz operators, the Riemann Liouville operator, and Grunwald-Letnikov operators(3). Typically, the operators generate both high and low frequencies with the high frequencies characterizing a large change in pixel intensity value over a small distance including noise and edges. In contrast, the low frequency is characterized by a small change in pixel intensity value where background and texture in the image can be found.

This means that, in the presence of high-level noise, some of these operators proposed, if not carefully constructed, will tend to mistakenly detect fake edges. In this paper, we present a new construction of fractional-based convolution mask for image edge analysis with equivalent complexity (-($mn\log(mn)$)) as the standard gradient operators but with significant robustness to noise. We also show that it is able to detect edges very well as a result of the memory (kernel) function embedded in the fractional derivative. These interesting characteristic allows the operator to describe systems with memory phenomena. The paper is organized as follows: we start by reviewing some edge detection operators in Section 2. Section 3 discusses the generalized fractional calculus operator adopted for this study and subsequently in Section 4 we show how the proposed mask is constructed. In Section 5, we compare results from the proposed mask with two methods known to perform well. Finally, conclusions are drawn in Section 6.

Image enhancement and image segmentation are the process performed in pre-processing stage(4). Image enhancement is used to improve the interpretability of information in the image to the human viewers. Image enhancement is of two types, spatial domain methods and frequency domain methods. Spatial domain method deals with the image pixel. Enhancement is achieved by changing the pixel values. That means, alternating the grey level value and change the contrast of the image. In frequency domain enhancement is achieved by changing the orthogonal transform of image. That means, based on the frequency domain the processing are performed. There are different methods for image enhancement. Gabor filter, Fast Fourier transform are the some of them. Gabor filter: Gabor filter was introduced by Dennis Gabor.

This method is mainly applied over 2D images. Gabor filter is a liner filter which has an impulse response. Impulse response is defined by multiplying a harmonic function with a Gaussian function. Fast Fourier transform: Fast Fourier transform is the faster version of Discrete Fourier transform. This method operates on the Fourier transform of the image. Fourier theory tells that an operation called convolution is performed in the frequency domain to enhance the image(5). A convolution in the frequency domain is a simple multiplication of an image mask with the complex frequency domain image.

II. EXISTING METHOD

The early detection of lung cancer can extend the lifetime of a patient about few years. The Lung Cancer providing to be a catastrophic Threat to the Mankind and is main cause of Human deaths among other cancer related casualties.

The most challenging problem in medical research is to detect in early stage of lung cancer. This is due to abnormal formation of cells which may be sometime overlap. The presence of solitary pulmonary nodules in human lungs are in the form of malignant determines the gravity of lung ailments. Image processing which is growing research Area has been playing a central role in the detection of lung cancer images. Among many imaging modalities CT leads to higher resolution Data acquisition First of all, normal and abnormal CT images are collected from the available database. On these dataset images, preprocessing is applied to get an enhanced image, which involves denoising, enhancement, segmentation etc. The preprocessing steps of the proposed system can identify the appropriate region affected by cancer. Preprocessing is the initial step for detecting the lung cancer.

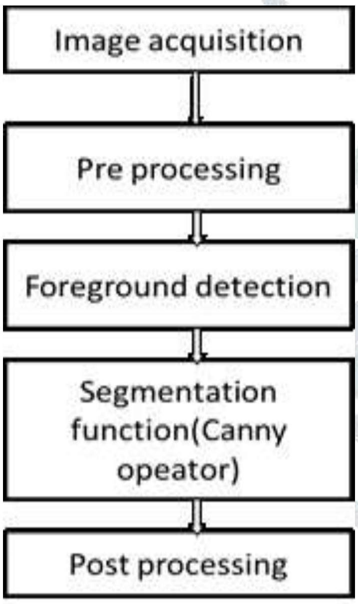


Fig.1 Block diagram for existing method

Image preprocessing is used to reduce noise and prepare the images for further steps such as segmentation. It diminishes distortion in image and enhances the relevant features. Thus a rectified image is obtained(6). The various steps involved in image processing are smoothing, image enhancement, and gray level conversion. Using this process most of the image analyzing task can be done subsequently. In specific, the present methods depend highly on the segmentation result for image description and recognition. But here we are using Watershed segmentation and thresholding. Obtained image after segmentation from thresholding had much significance like fast processing speed less storage space and simply by manipulation of 256 levels of grey level image. The most important stage in this method is to isolate various preferred shapes or portions of the image. In image processing methods, different algorithms are used to determine normality and abnormality of an image from the final result of segmentation10. The area, perimeter, eccentricity and average intensity are main features helps to form the classification of cancer region.

III. PROPOSED METHOD

The proposed system focus on detection of Lung cancer from CT image which is automatically detects Lung cancer. The system based on computer vision that is used to detect the Lung cancer. The main contribution of this paper is to develop the rotation, scaling and translation invariant feature extraction method for detection of Lung cancer. The main contribution of this project is to use Fractional Calculus for identifying the edges and extract the tumor from lung cancer images.

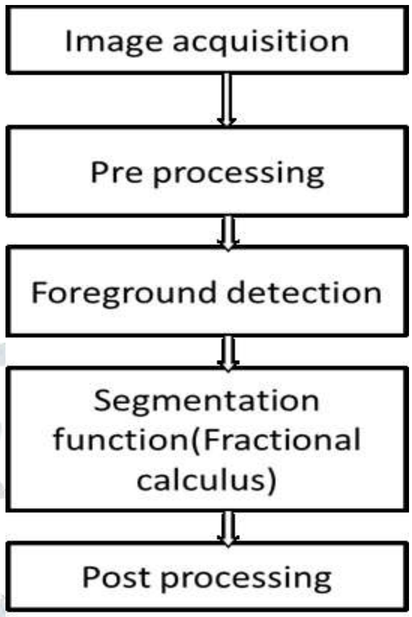


Fig.2 Block diagram for proposed method

Image acquisition:
In conventional X-ray imaging, the entire thickness of the body is projected on a film: structures overlap and are difficult to distinguish. One of the problems is the loss of information about depth. Suppose a small lung carcinoma can be seen at a front-to-back chest photograph. But where is it? The radiologist cannot determine the exact location of this carcinoma in the forward backward direction. One could make a lateral photograph (a side view), but the carcinoma might disappear behind a rib. What is needed in such a case is a cross-sectional image.

Preprocessing and Foreground Detection:
The preprocessing includes image conversion from RGB to Gray scale, filtering to remove noise and thresholding to make the image ready for edge detection.

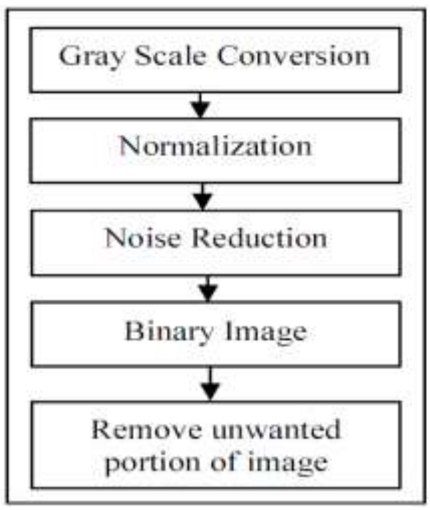


Fig.3 Block Diagram of image preprocessing

The Morphological operations have been used for foreground detection(7). The image smoothing is also performed after conversion into gray scale image to diminish the effects of noise, spurious pixel values, missing pixel values etc. There are many different techniques for image smoothing. The neighborhood averaging and edge-preserving smoothing are used in image smoothing.

Fractional Calculus:
Fractional calculus is a branch of mathematical analysis that studies the possibility of taking real number, or even complex number, powers of the differential operator
D=dy/dx
and the integration operator J. (Usually J is used in favor of I to avoid with other I-like identities) .In this context powers refer to iterative application or composition, in the same sense that
$f^2(x) = f(f(x))$
For example, one may pose the question of interpreting meaningfully
$\sqrt{D} = D^{1/2}$
As a square root of the differentiation operator (an operator half iterate), i.e., an expression for some operator that when applied twice to a function will have the same effect as differentiation.

Riemann-Liouville Theorem:
Typically, the operators generate both high and low frequencies with the high frequencies characterizing a large change in pixel intensity value over a small distance including noise and edges. In contrast, the low frequency is characterized by a small change in pixel intensity value where background and texture in the image can be found. These operators are usually categorized as the gradient-based edge detectors, segmentation-based edge operators and the transform based edge operators. The first category of edge detectors are mostly based on either first-order gradient operators or second-order operators,
sometimes called Laplacians. According to although higher orders are more accurate compared with first order operators, it is relatively sensitive to noise when extracting relatively more information(8). For example gradient-based edge detection operators, such as the Roberts, Sobel, and Prewitts, Laplacian of Gaussian (LoG) and their improvements uses 2-D linear filters to process vertical and horizontal edges separately in order to approximate the first-order derivative of pixel values of an image.
The whole system of lung cancer detection divided into following steps Image Acquisition, Image Preprocessing, Edge detection using fractional derivative, Morphological operation and Feature Extraction.

Edge Mask Representation:
Since the Riemann-Liouville fractional derivative mask is the desired operator of interest for our image edge analysis, equation (1) is considered. However, this equation cannot be directly applied to an image in
its one-dimensional form and needs to be transformed into two dimensions. This is achieved by letting

$$z \rightarrow \sqrt{x^2 + y^2}.$$

Table 1: Proposed x-directional fractional mask

$\frac{2\alpha\sqrt{8^\alpha}}{8\Gamma(1-\alpha)}$	$\frac{\alpha\sqrt{5^\alpha}}{5\Gamma(1-\alpha)}$	0	$\frac{-\alpha\sqrt{5^\alpha}}{5\Gamma(1-\alpha)}$	$\frac{-2\alpha\sqrt{8^\alpha}}{8\Gamma(1-\alpha)}$
$\frac{2\alpha\sqrt{5^\alpha}}{5\Gamma(1-\alpha)}$	$\frac{\alpha\sqrt{2^\alpha}}{2\Gamma(1-\alpha)}$	0	$\frac{-\alpha\sqrt{2^\alpha}}{2\Gamma(1-\alpha)}$	$\frac{-2\alpha\sqrt{5^\alpha}}{5\Gamma(1-\alpha)}$
$\frac{2\alpha\sqrt{4^\alpha}}{4\Gamma(1-\alpha)}$	$\frac{\alpha}{\Gamma(1-\alpha)}$	0	$\frac{-\alpha}{\Gamma(1-\alpha)}$	$\frac{-2\alpha\sqrt{4^\alpha}}{4\Gamma(1-\alpha)}$
$\frac{2\alpha\sqrt{5^\alpha}}{5\Gamma(1-\alpha)}$	$\frac{\alpha\sqrt{2^\alpha}}{2\Gamma(1-\alpha)}$	0	$\frac{-\alpha\sqrt{2^\alpha}}{2\Gamma(1-\alpha)}$	$\frac{-2\alpha\sqrt{5^\alpha}}{5\Gamma(1-\alpha)}$
$\frac{2\alpha\sqrt{8^\alpha}}{8\Gamma(1-\alpha)}$	$\frac{\alpha\sqrt{5^\alpha}}{5\Gamma(1-\alpha)}$	0	$\frac{-\alpha\sqrt{5^\alpha}}{5\Gamma(1-\alpha)}$	$\frac{-2\alpha\sqrt{8^\alpha}}{8\Gamma(1-\alpha)}$

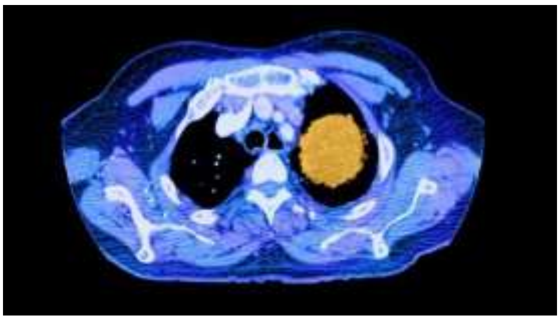
Table 2: Proposed y-directional fractional mask

$\frac{2\alpha\sqrt{8^\alpha}}{8\Gamma(1-\alpha)}$	$\frac{2\alpha\sqrt{5^\alpha}}{5\Gamma(1-\alpha)}$	$\frac{2\alpha\sqrt{4^\alpha}}{4\Gamma(1-\alpha)}$	$\frac{2\alpha\sqrt{5^\alpha}}{5\Gamma(1-\alpha)}$	$\frac{2\alpha\sqrt{8^\alpha}}{8\Gamma(1-\alpha)}$
$\frac{\alpha\sqrt{5^\alpha}}{5\Gamma(1-\alpha)}$	$\frac{\alpha\sqrt{2^\alpha}}{2\Gamma(1-\alpha)}$	$\frac{\alpha}{\Gamma(1-\alpha)}$	$\frac{\alpha\sqrt{2^\alpha}}{2\Gamma(1-\alpha)}$	$\frac{\alpha\sqrt{5^\alpha}}{5\Gamma(1-\alpha)}$
0	0	0	0	0
$\frac{-\alpha\sqrt{5^\alpha}}{5\Gamma(1-\alpha)}$	$\frac{-\alpha\sqrt{2^\alpha}}{2\Gamma(1-\alpha)}$	$\frac{-\alpha}{\Gamma(1-\alpha)}$	$\frac{-\alpha\sqrt{2^\alpha}}{2\Gamma(1-\alpha)}$	$\frac{-\alpha\sqrt{5^\alpha}}{5\Gamma(1-\alpha)}$
$\frac{-2\alpha\sqrt{8^\alpha}}{8\Gamma(1-\alpha)}$	$\frac{-2\alpha\sqrt{5^\alpha}}{5\Gamma(1-\alpha)}$	$\frac{-2\alpha\sqrt{4^\alpha}}{4\Gamma(1-\alpha)}$	$\frac{-2\alpha\sqrt{5^\alpha}}{5\Gamma(1-\alpha)}$	$\frac{-2\alpha\sqrt{8^\alpha}}{8\Gamma(1-\alpha)}$

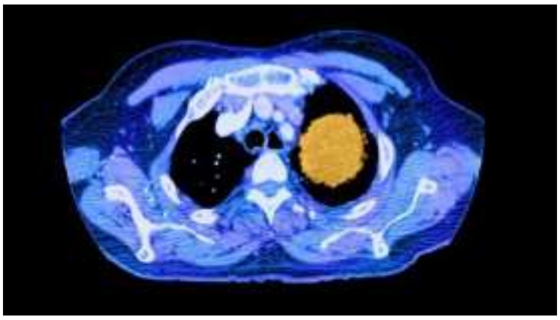
The proposed gradient operators in the direction of *x* and *y*, respectively, in two dimensional (2D) form,

$$\Theta_x(x,y) = \frac{1}{\Gamma(1-\alpha)}\frac{d}{dx}\left(x^2+y^2\right)^{-\alpha/2}, \quad 0 \le \alpha < 1$$
$$= -\frac{\alpha \cdot x}{\Gamma(1-\alpha)}\left(x^2+y^2\right)^{-\alpha/2-1},$$
$$\Theta_y(x,y) = \frac{1}{\Gamma(1-\alpha)}\frac{d}{dy}\left(x^2+y^2\right)^{-\alpha/2}, \quad 0 \le \alpha < 1$$
$$= -\frac{\alpha \cdot y}{\Gamma(1-\alpha)}\left(x^2+y^2\right)^{-\alpha/2-1}.$$

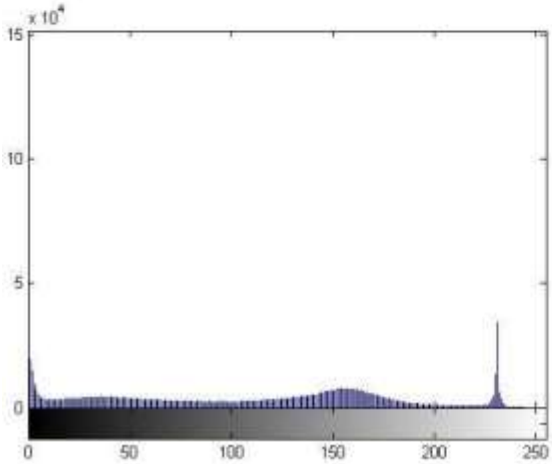
IV. RESULTS
The special type of digital X-Ray machine is used to acquire detailed Pictures or scans of areas inside the body called computerized tomography (CT). Computed tomography is an imaging procedure. The system has been collected total 300 Lung CT images that are cancer and normal image of lung from the Internet and Hospital. The system used Lung CT images that are jpeg file format. After Image Acquisition, images are passed through the image preprocessing steps. The stage wise processed images are given in *Fig.4*. The RGB image converted into gray scale image by using the Matlab function rgb2gray. It converts RGB image or color image to grayscale by eliminating thehue and saturation information while retaining the luminance. Normalize the acquired image by using the Matlab function imresize(9). The system uses imresize function with the value of 150 x 140 pixels and 200 x 250 pixels. This size gives enough information of the image when the processing time is low. To remove the noise the system used median filter i.e. medfilt2. Medfilt2 is 2-D median filter. Median filtering is a nonlinear operation often used in image processing to reduce "salt and pepper" noise. A median filter is more effective than convolution when the goal IS to simultaneously reduce noise and preserve edges. Noise free gray scale image is converted to binary image, that is an image with pixels O's (white) and 1's (black). To convert gray scale image into binary image, the system use the Matlab function im2bw. Converting into binary image, we have to remove the unnecessary pixels (0) from original image. This is done because we need to develop size independent algorithm. The threshold value for converting the gray scale image into binary image has been chosen based on the histogram. The small valley can be observed in the histogram and decided the threshold value.



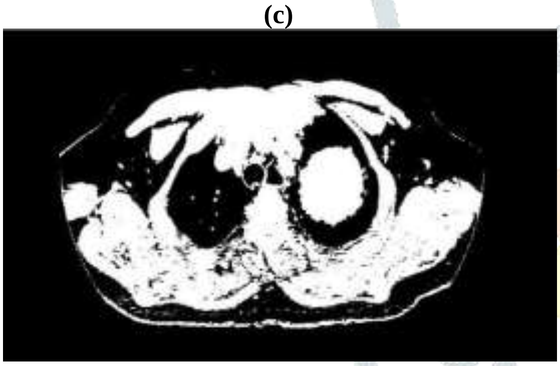
(a)



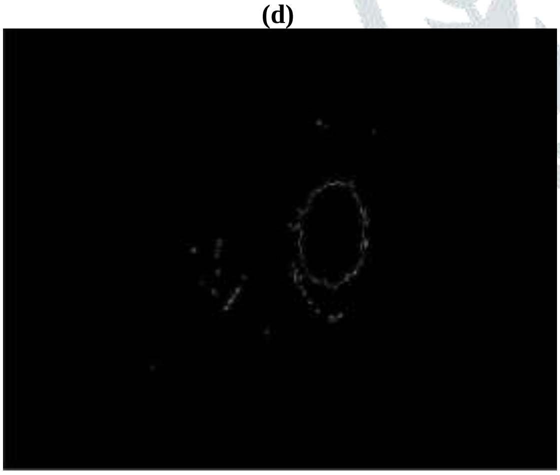
(b)



(c)

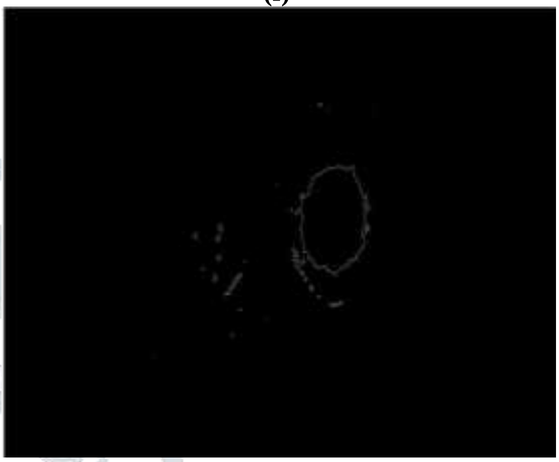


(d)



(e)

(f)



(g)

X-directional fractional mask:

u =

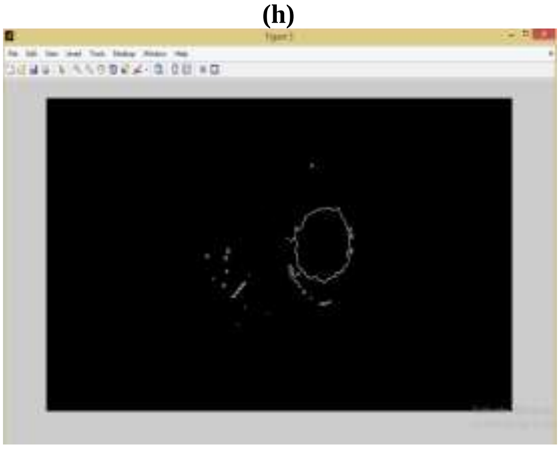
0.0419	0.0377	0	-0.0377	-0.0419
0.0755	0.1186	0	-0.1186	-0.0755
0.0997	0.2821	0	-0.2821	-0.0997
0.0755	0.1186	0	-0.1186	-0.0755
0.0419	0.0377	0	-0.0377	-0.0419

Y-directional fractional mask:

v =

0.0419	0.0755	0.0997	0.0755	0.0419
0.0377	0.1186	0.2821	0.1186	0.0377
0	0	0	0	0
-0.0377	-0.1186	-0.2821	-0.1186	-0.0377
-0.0419	-0.0755	-0.0997	-0.0755	-0.0419

(h)



(i)

X-directional fractional mask:

u =

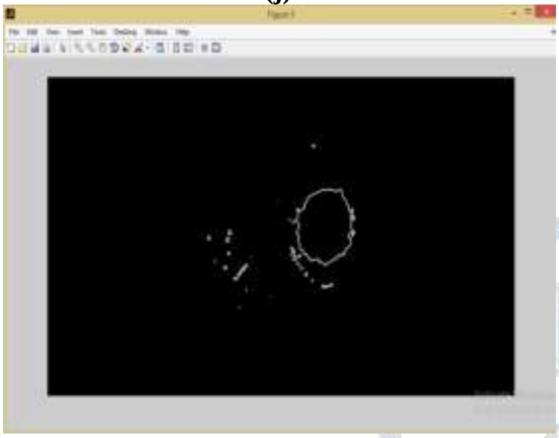
0.0228	0.0229	0.0159	0	-0.0159	-0.0229	-0.0228
0.0343	0.0419	0.0377	0	-0.0377	-0.0419	-0.0343
0.0476	0.0755	0.1186	0	-0.1186	-0.0755	-0.0476
0.0543	0.0997	0.2821	0	-0.2821	-0.0997	-0.0543
0.0476	0.0755	0.1186	0	-0.1186	-0.0755	-0.0476
0.0343	0.0419	0.0377	0	-0.0377	-0.0419	-0.0343
0.0228	0.0229	0.0159	0	-0.0159	-0.0229	-0.0228

Y-directional fractional mask:

v =

0.0228	0.0343	0.0476	0.0543	0.0476	0.0343	0.0228
0.0229	0.0419	0.0755	0.0997	0.0755	0.0419	0.0229
0.0159	0.0377	0.1186	0.2821	0.1186	0.0377	0.0159
0	0	0	0	0	0	0
-0.0159	-0.0377	-0.1186	-0.2821	-0.1186	-0.0377	-0.0159
-0.0229	-0.0419	-0.0755	-0.0997	-0.0755	-0.0419	-0.0229
-0.0228	-0.0343	-0.0476	-0.0543	-0.0476	-0.0343	-0.0228

(j)



(k)

X-directional fractional mask:

u =

0.0148	0.0131	0.0133	0.0062	0	-0.0062	-0.0133	-0.0131	-0.0148
0.0202	0.0228	0.0229	0.0159	0	-0.0159	-0.0229	-0.0228	-0.0202
0.0267	0.0343	0.0419	0.0377	0	-0.0377	-0.0419	-0.0343	-0.0267
0.0327	0.0476	0.0755	0.1186	0	-0.1186	-0.0755	-0.0476	-0.0327
0.0353	0.0543	0.0997	0.2821	0	-0.2821	-0.0997	-0.0543	-0.0353
0.0327	0.0476	0.0755	0.1186	0	-0.1186	-0.0755	-0.0476	-0.0327
0.0267	0.0343	0.0419	0.0377	0	-0.0377	-0.0419	-0.0343	-0.0267
0.0202	0.0228	0.0229	0.0159	0	-0.0159	-0.0229	-0.0228	-0.0202
0.0148	0.0131	0.0133	0.0062	0	-0.0062	-0.0133	-0.0131	-0.0148

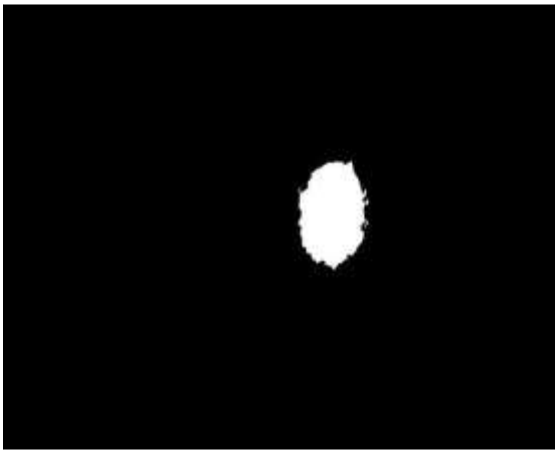
Y-directional fractional mask:

v =

0.0148	0.0202	0.0267	0.0327	0.0353	0.0327	0.0267	0.0202	0.0148
0.0131	0.0228	0.0343	0.0476	0.0543	0.0476	0.0343	0.0228	0.0131
0.0133	0.0229	0.0419	0.0755	0.0997	0.0755	0.0419	0.0229	0.0133
0.0062	0.0159	0.0377	0.1186	0.2821	0.1186	0.0377	0.0159	0.0062
0	0	0	0	0	0	0	0	0
-0.0062	-0.0159	-0.0377	-0.1186	-0.2821	-0.1186	-0.0377	-0.0159	-0.0062
-0.0133	-0.0229	-0.0419	-0.0755	-0.0997	-0.0755	-0.0419	-0.0229	-0.0133
-0.0131	-0.0228	-0.0343	-0.0476	-0.0543	-0.0476	-0.0343	-0.0228	-0.0131
-0.0148	-0.0202	-0.0267	-0.0327	-0.0353	-0.0327	-0.0267	-0.0202	-0.0148

(l)

(m)



(n)

Fig.4: Tumor extraction process (a) Original Image, (b) Gray scale Image, (c) Histogram of b, (d) Threshold Image, (e) Sobel edge detection for d, (f) Canny edge detection for d, (g) Proposed edge detection with 3x3 mask, (h) 5x5 masks, (i) Proposed edge detection with 5x5 mask, (j) 7x7 masks, (k) Proposed edge detection with 7x7 mask, (l) 9x9 masks, (m) Proposed edge detection with 9x9 mask, (n) Extracted Tumor.

V. CONCLUSION

Another way of constructing a fractional-based convolution mask for image edge analysis using the Riemann-Liouville fractional derivative formulation is presented in this project. Unlike other constructions, the extraction of the mask is done, maintaining enough memory without the need for complicated optimization criteria. The edge detection using fractional derivatives has been compared with standard edge detection method i.e. canny. The proposed edge detection technique identifies both Dirac edges and hidden edges found in the images has been calculated and applied simultaneously without need of any physical calculations In addition, it is also shown that the resulting mask is robust to noise.

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