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DESIGN AND DEVELOPMENT OF IMAGE PROCESSING TOOL FOR ENHANCING THE LUNG TUMOR MRI IMAGE

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ABSTRACT Lung cancer tumors obliterate healthy tissues around them and metastasize to other organs. Early detection of these tumors holds the key in the survival of the patients with little or no recurrence. Image processing techniques enhance the quality of biomedical images of cancer tumors. In this paper, we designed and developed a tool to enhance the quality of MRI tumor image for its accurate detection by applying 16 image filters like Mean, Median, Gaussian etc using MATLAB. Their performance was validated using image comparison indices: mean square error (MSE), peak signal to noise ratio (PSNR) and structural similarity index (SSIM) values. Weiner filter efficiently enhanced the image quality compared to other filters based on MSE (1.24) and PSNR (47.22) values. Based on SSIM value (1) the average filter was found to be optimum. This tool can be utilized for real-time application in cancer diagnosis and treatment.

KEYWORDS : Image Processing, MRI Image enhancement, MATLAB, Lung cancer

1 INTRODUCTION

Lung cancer is estimated to be one of the predominant reasons for 7.6 million global deaths in humans annually, and its incidence is estimated to reach 21.4 million by 2030 (1). Apparently, many of these deaths could have been possibly avoided with early detection based on better biomedical image processing techniques. Cancer tumors are highly vascular and they obliterate healthy tissues around them. If not detected early and treated, this growth spreads to other tissues through metastasis and form secondary tumors in other organs. Therefore, early detection of lung cancer tumors and their efficient treatment holds the key in the eventual survival of the patients over five years, with little or no recurrence (2).

Health care sector is one of the crucial domains that require interdisciplinary research and development, more pertinently in diagnosis and biomedical imaging processes. A perusal of the available literature suggests that image pre-processing/processing techniques are mostly used for early detection of lung cancer (3). Recent studies reported that image pre-processing techniques are crucial in the early detection of lung cancer (4). Image filtration by using median filter was also shown to enhance the quality of image for early stage detection of lung cancer (5). Computer based techniques can effectively identify/diagnose tumors in several types of biomedical images (6).

Significantly, many biomedical images, satellite, aerial images including photographic pictures exhibit reduced and awful contrast and noise. Noise degrades the image during its capture or transmission. Therefore, de-noising is crucial to enhance the image quality. In recent times, significant technical advances are made in de-noising of digital images. For instance, current research (2) demonstrated that tumors can be diagnosed early using robust computational procedures, different noise elimination by segmentation strategies and calculations. BM3D filter coupled with block-matching to remove salt-and-pepper noise and refine the digital images was also used (7). The results are highly promising both for grayscale and color images.

Apparently, image processing techniques offer a great scope to enhance the quality of biomedical images of lung cancer tumors for their early detection (8). Research is warranted to develop scientifically sound and utility tools for image processing to empower medical professionals in early detection of lung cancer tumors using MATLAB. In the light of this, we designed and developed an image processing tool for enhancing the quality of lung tumor MRI Image by applying around 16 pre-defined image filtering techniques like Mean, Median, Gaussian etc using MATLAB. The quality of output filtered images with input images were validated by their corresponding MSE, PSNR and SSIM indices to assess the filter efficiency in removing certain types of noises. We hypothesize that this tool has potential for real-time application in lung cancer diagnosis and treatment.**2**

MATERIALS AND METHODS

In this investigation, the following methodology was adopted to enhance the quality of MRI images of lung cancer tumor.

2.1 Image enhancement techniques

Image enhancement techniques improve an image, wherein the improvement can be objective or subjective. For instance, they can either increase the signal-to-noise ratio of an image, or distinguish certain features by modifying the colors or intensities (8). Typically, image enhancement operations modify the original image yielding a superior version which is frequently used as a preprocessing step to improve the results of image analysis (7). In view of this, we applied 16 filters viz., median, weiner, unsharp masking, laplacian, guided, average, range, motion, disc, sobel edged emphasis, LOG, gaussian, max, min, midpoint, gabor for enhancing the MRI scan image of lung cancer tumor. The MRI image was obtained from web source.

2.2 Image comparison metrics

To validate the performance of the different filters used for the enhancement of tumor MRI images, we used three image comparison metrics Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR) and Structural Similarity Index (SSIM).

These indices are extensively used to resolve the extent of image distortion since they embody the overall gray-value errors of the entire image, which is calculated using the eq 1 (8).

MSE is effective when additive noise distorts the image. The MSE is the cumulative squared error between the compressed and the original image (eq 1).

$$MSE = \frac{1}{MN} \sum_{y=1}^{M} \sum_{x=1}^{N} [I(x,y) - I'(x,y)]^2$$

Wherein, I (x, y) is the original image, I'(x, y) is the filtered version, M, N are the dimensions of the images. A lower value of MSE indicates lesser error.

PSNR measures the quality of compressed images. The original data acts as a signal while the noise corresponds to the inaccuracy

introduced by filtering. The PSNR is determined using the formula:
PSNR = 20 * log10 (255 / sqrt (MSE)) (2)

SSIM is employed to assess the resemblance between two images. The image quality can be predicted by referring to the original uncompressed image sans distortion. Whilst MSE or PSNR estimate absolute errors, SSIM perceives change in image degradation by incorporating important phenomena like luminance masking and contrast masking terms. The SSIM index is calculated on various windows of an image. The measure between two windows and of common size N×N is

$$\mathrm{SSIM}(x,y) = \frac{(2\mu_x\mu_y + c_1)(2\sigma_{xy} + c_2)}{(\mu_x^2 + \mu_y^2 + c_1)(\sigma_x^2 + \sigma_y^2 + c_2)}$$

Usually, the quality of the image is evaluated by applying this formula only on luma. However, it could also be applicable to color values (red, green, blue). SSIM index ranges between -1 and 1 values, but 1 is attainable among two sets of similar data

2.3 Graphical user interface (GUI)

Graphical user interface offers the user an interactive environment to compute and converse with other UI's, plot graphs, create tables etc. MATLAB GUI comprises many user interface tools (9)**.** In this study, we used the load image pushbutton to select an input image from any folder present in the MATLAB directory and display it in the axes1 region. The RGB to GRAY pushbutton is used to convert any color pixels present in the input image into grayscale. The grayscale image is displayed on the axes2 region. Several filtering techniques are applied using 16 push buttons each having a function of a particular filter viz., median, weiner, unsharp masking, Laplacian, guided, average, range, motion, disc, sobel edged emphasis, LOG, Gaussian, max, min, mid point, gabor for enhancing the MRI image of lung cancer tumor, and the resultant filtered image is displayed in axes3 region. The image comparison metrics namely MSE, PSNR and SSIM for each filtered image are displayed in the command window of MATLAB. The image comparison metric values of all the filtered images are tabulated and a graph is plotted to display the variations in these values for various filtered output images. The .fig file is saved and the callback functions are assigned for all the components placed on the panel of the GUI. After the GUI is designed and callbacks are defined, the file is executed and the input tumor image from the system is taken and displayed on the axes present in the GUI. Subsequently, various filters are employed to augment the lung tumor image quality. Fig 1 illustrates the GUI employed in this investigation.

3 RESULTS

In this study, we applied 16 image filtering techniques on MATLAB. Moreover, the performance of various filters was validated using image comparison indices like mean MSE, PSNR and SSIM values and the corresponding data were presented (Table 1). The results indicated that Weiner filter was more efficient followed by median filter in enhancing the image quality compared to other filters based on MSE (1.24) and PSNR (47.22) values. However, based on SSIM value (1) the average filter was found to be optimum.

4. DISCUSSION

Lung cancer develops as a tiny round or ellipsoid growth on the lung which usually manifests in the CT scan as a white patch. If not detected early and treated, this growth spreads to other tissues through metastasis and forms secondary tumors. Therefore, early detection of tumors and their efficient treatment holds the key in the eventual survival of the patients**.** In this pursuit, many researchers worked on using image processing techniques to develop lung cancer detection systems. Image processing techniques were employed to detect/classify various lung cancer stages on CT scan images using MATLAB (7). They reported an increase in survival rate (14 to 49%) of lung cancer patients whose cancer is detected early. According to (10), the main features of accuracy for image comparison are pixels percentage and mask-labeling. In another study (11), the image quality was enhanced using morphological transformations using MATLAB simulation model.

Noise degrades the image during its capture or transmission. Therefore, de-noising is crucial to enhance the image quality. In recent times, significant technical advances are made in de-noising of digital images. The quality of de-noised images was studied by MSE and its related metrics PSNR, RMSE and SNR (12). They also assessed the structural changes that occur during the denoising process which can provide an alternative metric for determining the quality of de-noised images. Globally, location of CT pictures received from cancer research organizations are investigated utilizing MATLAB.

In the light of the above facts, we designed and developed an image processing tool to enhance the quality of MRI tumor image for its accurate detection by applying 16 image filtering techniques like Mean, Median, Gaussian etc using MATLAB. The results indicated that Weiner filter was more efficient in enhancing the image quality followed by median filter compared to other filters based on MSE (1.24) and PSNR (47.22) values. However, based on SSIM value (1) the average filter was found to be optimum. Figure 1 illustrates that this tool successfully enhanced the quality of MRI images of lung cancer tumor and has huge potential for real-time application in cancer diagnosis and treatment.

CONCLUSION

To enhance the MRI lung cancer tumor image, we developed an image processing tool using MATLAB for pre-processing of the image. In addition, the filtered images are validated using image processing metrics. Image processing techniques offer a great scope to enhance the quality of biomedical images of cancer tumors for their early detection. The image processing tool developed by us successfully enhanced the quality of MRI images of lung cancer tumors and has huge potential for real-time application in cancer diagnosis and treatment. Further studies are required to assess the image quality by deploying hybrid filtering techniques which facilitates effective detection of lung cancer tumors.

Table 1. Performance validation of filters using image comparison metrics

S.No	Filter	MSE	PSNR	SSIM
1	MEDIAN	1.67	45.95	0.988
2	WIENER	1.24	47.22	0.986
3	AVERAGE	6.142	36.74	1
4	GUIDED	6.82	39.82	0.948
5	MIDPOINT	7.81	39.23	0.957
6	MOTION	12.61	37.15	0.913
7	GAUSSIAN	14.5	36.55	0.911
8	UNSHARP	16.05	36.10	0.894
9	LAPLACIAN	24.89	34.20	0.745
10	DISK	36.08	32.59	0.736
11	MIN	39.78	32.16	0.905
12	SOBEL	216.75	24.80	0.138
13	RANGE	219.68	24.74	0.189
14	LOG	222.72	24.68	0.100
15	MAX	0	INF	0.905

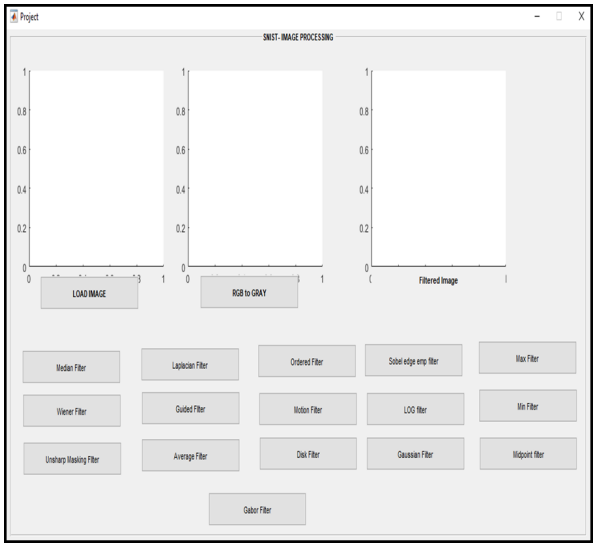


Fig 1. GUI used in the present study

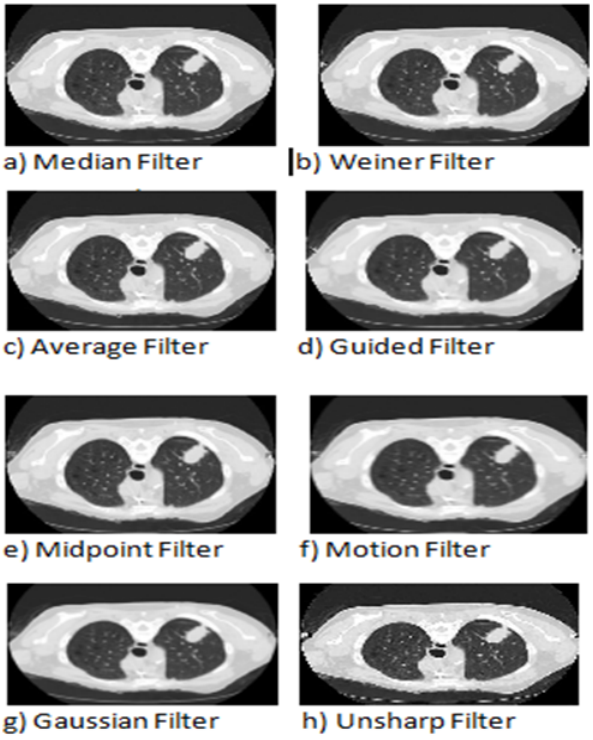
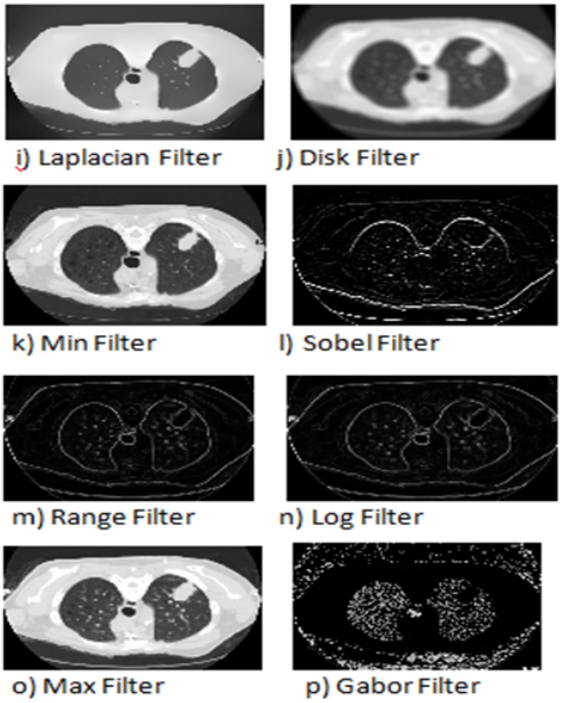


Fig 2 a-p. Enhanced quality of MRI images of lung cancer tumor using the image processing Tool developed in this study



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