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MRIDetect: Improved MRI Image Brain Tumor Detection Implementing Techniques for Piecewise Linear Transformation

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***Abstract*—Effective treatment of brain tumors greatly depends on timely intervention and prompt identification of the disease. Most traditional image processing approaches have a particular challenge in augmenting the detection of tumors on MRI images, which may result in misdiagnosis or no diagnosis at all. In this research, we focus on enhancing finding a brain tumors MRI images through the use in piecewise linear transformation techniques. The proposed method detects and defines certain intensity values and adds custom linear transformations so that the contrast of tumor tissues with other brain structures is maximized. A large number of experiments conducted with the proposed method of MRI images improved that the detection of tumors is increased, hence improving the diagnosis. MRI images that need better detection features can employ this method for accurate evaluation. The findings suggest that utilizing piecewise linear transformation in MRI imaging can effectively enhance the detection of brain tumors and regions of interest in an effortless approach. Several methods encompassing line stretch, bi-linear stretch and global stretching collectively, or various linear piecewise techniques, stretch the contrast of images depicting the brain with tumors so that the most features possible may be observed. These methods are critical as they allow clearer visibility of fine details that would be otherwise not observable. When it comes to techniques for expanding an image's intensity range, contrast stretching and linear contrast stretching change. While the two methods apply linear transformations to certain intensity ranges, bi-linear transform stretching uses two ranges. The tuning of the intensity values is known as contrast adjustment. These methods improve the visibility of the tumor aiding in its detection and evaluation by increasing the contrast between tumor tissues and surrounding brain structures. These techniques greatly aid medical imaging in diagnosing issues with improved precision. The MRI images of brain tumors processed using these methods showed remarkable clarity improvements, verifying the techniques' significance in medical imaging.**

***Index Terms*— MRI Medical Images, Contrast enhancement Algorithm, Contrast Stretching and Linear Contrast Stretching.**

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I. INTRODUCTION

Image quality is the most critical aspect of diagnosis and analysis in medical imaging, especially for MRI scans of brain tumors. In this area, image quality is significantly improved by utilizing contrast stretching (CS), linear contrast stretching (LCS), bi-linear contrast stretching (BLCS) and contrast adjustment methods. These techniques increase the intensity ranges of the images so that tumor tissues are more visually distinct from the surrounding brain structures. Some of the major parameters that define the quantification of the evaluated techniques and methods effectiveness are PSNR, SNR and SSIM. PSNR is used for determining to accuracy of the modified image with reference to the original, SNR shows the amount of noise in the system when the desired signal is present, and SSIM determines how the image is perceived. With the provided data, the effectiveness of techniques used in contrast enhancement in MRI scans of brain tumors can be evaluated determinatively.

II. LITERATURE REVIEW

Randeep Kaur et al. This study examines and compares the performance of several contrast enhancement strategies for medical images, The goal of this work is to discover which approach improves the quality and clarity of medical pictures the most by assessing the PSNR, MSE, NC, and RMSE metrics. The objective is to develop image processing technologies for medical diagnosis and analysis by maximizing contrast enhancement approaches.[1]

Komal Vij et al. This report aims to discuss the role of information brought in by histogram processing techniques for Contrast enhancement; identify the problem of low visibility and Contrast of Images; investigate possibilities and methods for revealing more detail in the image; examine the practical effectiveness and feasibility, as well as noise and user intervention amplification thresholds of various enhancement methods with constraints for defined image processing applications.[2].

Li Lu and associates. This research compares the effectiveness of five distinct histogram equalization (HE) methods for improving images. These are HE Itself, bi-histogram equalization (BBHE), Multi-histogram equalization based on logarithmic transform histogram shifting (LTHS), logarithmic transform histogram matching (LTHM), and the human visual system (HVS). In order of impartially assess to enhancement efficiency of different HE-based algorithms. This will provide a standard method for determining how much the quality of images is improved by different methods. [3].

Megha Sharma and associates. Their research primarily focuses on comparing various image enhancement systems to enhance the quality of chest X-ray images taken by medical devices. This purpose of the research to assess the median filter, DCT, and DWT techniques reduce noise and enhance contrast in chest X-ray images. The second objective is to measure the image quality using MSE, PSNR, and AMBE for various sets of enhancement techniques in order to determine which is best for medical diagnosis.[4]

Harpreet Kaur et al. The goal of study was investigated to role of histograms in image enhancement operations. Look into the three important basic methods of histogram processing: histogram equalization, histogram stretching, and histogram sliding. Analyzed factors associated with these methods of histogram processing and the results of image enhancement. Conduct a subjective assessment in order to understand how histogram processing technique impact image enhancement and highlight the possible uses of the techniques. Evaluate to effectiveness and applicability of the image Enhancement Techniques of sliding, stretching, and equalization of histograms. Explain in detail the roles of histogram features on delineation of photo-vision improvement of defined regions.[5]

Vijay Panse et al. Assist the physician in better visualization for diagnosing the disease by improving the contrast of CT, MRI, mammography, and X-ray images. To tackle the issue of low contrast ratio in medical images, create a hybrid method that integrates Brightness Preserving Dynamic Histogram Equalization (BPDHE) with contrast stretching (CS). Carry out a method that entails noise suppression pre-processing phase, accurate background estimation, foreground image extraction, local contrast stretching,[6]

III. PROPOSED WORK

The current study intends to enhance the appearance and improve the diagnostic value of MRI images of brain tumors using advanced Contrast Enhancement methods, such as contrast stretching (CS), linear contrast stretching (LCS), bi-linear contrast stretching (BLCS) and Contrast modification. Each method will be applied in sequence in order to maximize the visibility of the tumors tissues relative to the surrounding brain structures in MRI image. The effectiveness of these methods will be evaluated objectively, In the terms of signal to noise ratio (SNR), peak signal to noise ratio (PSNR) and structural similarity index (SSIM). SNR will estimate how clear the signal is compared to the noise, SSIM will estimate the perceived quality in terms of structural fidelity, and PSNR will assess how accurate the modify the images are comparison of the original images. This is the initial objective of the proposed study; determine the best contrast enhancement method assessment decision.

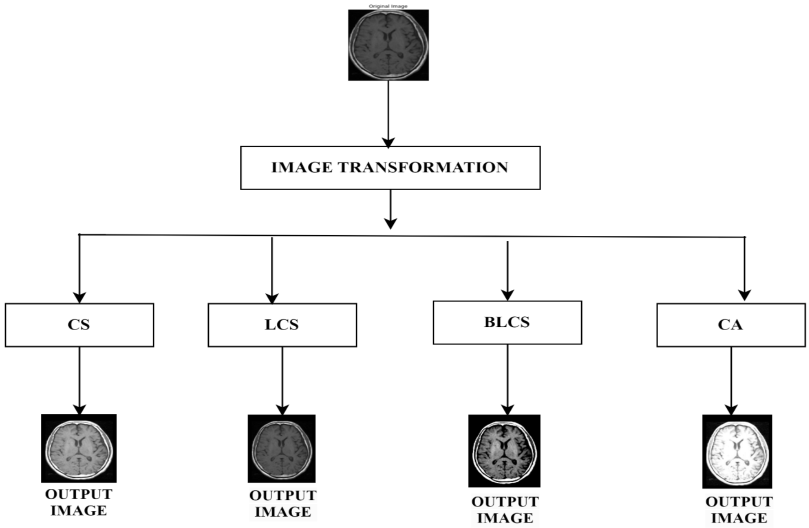


Fig. 1 General Architecture Diagram for Image Transformation

A. Contrast Stretching

In image processing, contrast stretching is a digital improvement method implemented for the purpose of modifying different types of anatomy structures and abnormalities in MRI images and scans, unlike other hystechnicians processes which is automatic. This research aims to achieve that goal by using the stretching technique for contrast transformation. Many medical images are of low quality because of the low radiation, exposure image acquisition or even noise. By increasing the value range of grayscale pixels, we contrast stretch to make the salient features and details stand out, enabling the enhancement of such images. This technique works by remapping pixel intensities from a narrow input range rmin and rmax to a wider output range smin and smax (usually 0 to 255 for gray scale images). A Linear function is used in the transformation process, whereby the intensities are spread out to enhance the contrast and ores, thus enables better differentiation of tissues. In medical image processing, contrast stretching can be represented mathematically as a transformation function.

$$s = T(r) \quad (1)$$

Where:

r is input pixel intensity (original medical image pixel value).

s is output pixel intensity (enhanced image pixel value).

T(r) is transformation function, that maps the input intensities of an expanded range for better contrast.

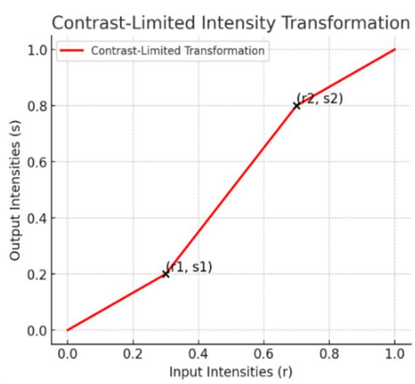


Fig.2(a) Before contrast stretching

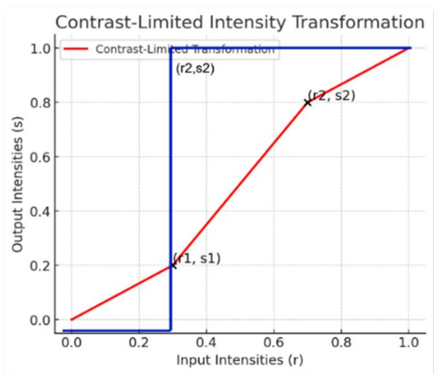
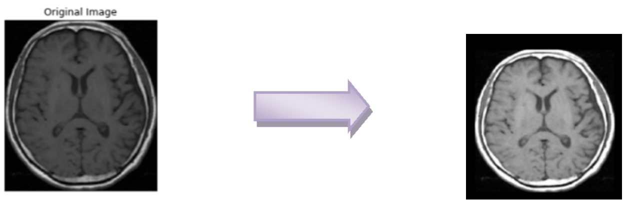


Fig.2(b) After contrast stretching



(c) (d)

Fig. 2 (c) Original brain tumor Image Fig.2 (d) After Contrast Stretching of brain tumor image

Here, the graph showing the intensity transformation curve. The red line represents the mapping of input intensities r to output intensity s while the blue dashed curve represents the modified transformation with contrast adjustments. The key points (r1, s1) and (r2, s2) are marked.

B. Linear Contrast Stretching (LCS)

To improve an image's contrast, a technique called Linear Contrast Stretching (LCS) maps the input intensity range [rmin,rmax] to an output range [smin,smax]. This adjustment allows intensity values to spread across the entire spectrum, thus increasing image visibility. Linear Contrast Stretching (LCS) is often applied in MRI (Magnetic Resonance Imaging) for better visualization of anatomical features for greater precision in diagnosing. Enhancing the contrast between Applying noise reduction while maintaining the integrity of critical structures.
The transformation function for LCS is:

$$s = \frac{(\mathrm{r}-r_{min})(s_{max}-s_{min})}{r_{max}-r_{min}} + s_{\mathrm{min}[7]} \quad (2)$$

where:
$r_{max} - r_{min}$ are the Minimum and Maximum pixel intensities of the original image.[7]
$s_{max} - s_{min}$ are desired output intensity range (typically 0 to 255 for grayscale medical images).

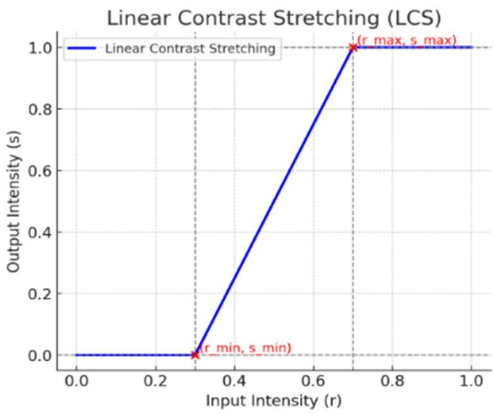


Fig.3(a) Linear Contrast Stretching

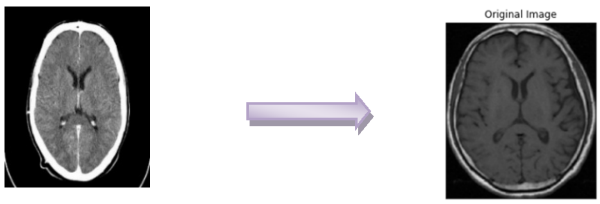


Fig. 3(b) Original brain tumor Image Fig.3(c) After Linear Contrast Stretching of brain tumors image

C. Bi-Linear Contrast Stretching (LCS)

The most advanced techniques for improve to image contrast is bi-linear contrast stretching, which uses two linear stretch operations on certain image intensity ranges. This approach is useful in medical imaging, for

example, MRI and CT scans, where various types of tissues have to be contrasted differently. The research introduced the Bi-Linear contrast transformation based on the process of contrast stretching. Better tissue differentiation in MRI scans: Useful for tumoral and brain structure lesions in medical imaging. Enhance bright and dark spaces while preserving average intensity.
Bi-Linear Contrast Stretching applies two linear transformations:

For the lower intensity range (r_{min} to r_m):

$$s = \frac{(r-r_{min})(s_{max}-s_{min})}{r_{max}-r_{min}} + s_{min} \tag{3}$$

For the higher intensity range (r_m to r_{max}):

$$s = \frac{(r-r_m)(s_{max}-s_m)}{r_{max}-r_m} + s_m \tag{4}$$

where:

r_{min}, r_{max} = Minimum and Maximum pixel of intensities to the input image.
r_m = Middle intensity value where the transformation changes.
s_{min}, s_{max} = Desired output intensity limits.
s_m = Output intensity corresponding to r_m.

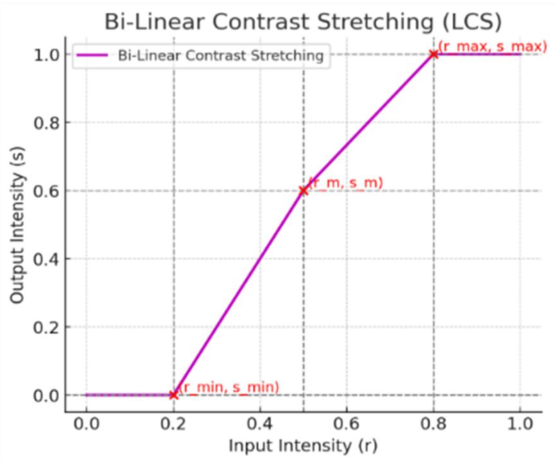


Fig.4(a) Bi Linear Contrast Stretching

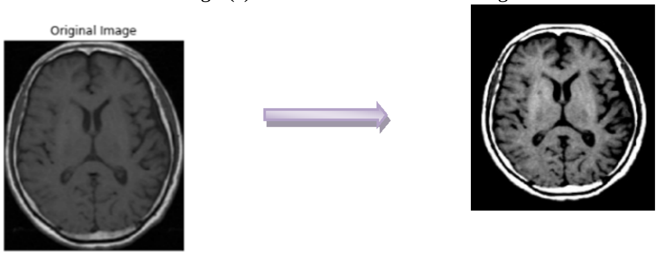


Fig. 4(b) Original brain tumor Image   Fig.4(c) After Bi-Linear Contrast Stretching of brain tumor image

D. Contrast Adjustment (CA)

Contrast Adjustment (CA) is one of the most routinely utilized techniques for improving the visibility of the lighter and darker areas of a given picture. It improves understanding of critical data, especially in medical imaging like MRI for brain tumor pictures, enhanced the region of interest in medical image, improves differentiation of the tissues (for example, structures in the brain on MRI), and diminishes noise and artifacts of low contrast images. CA utilizies expansion, compression, or shifting the pixel intens of the improve the visibility of a MRI image, as well as other images.

Expands pixel intensity range to increase contrast.

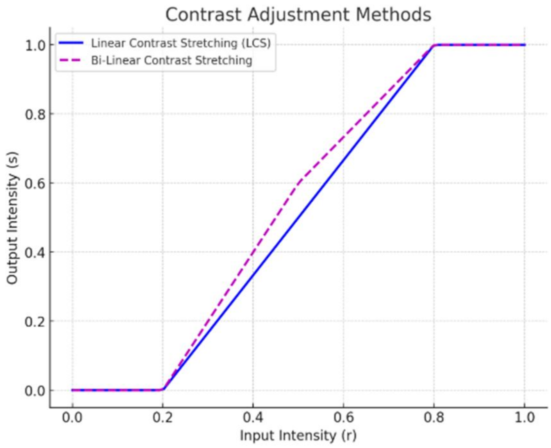


Fig.5(a) Contrast Adjustment

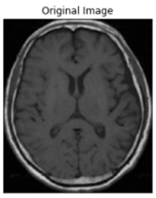


Fig. 5(b) Original brain tumor Image

Fig.5(c) After Contrast adjustment of brain tumor image

IV. Result and Discussion

To achieve better clarity and the ability to differentiate between different tissue locations, contrast stretching was applied to the MRI images. The following findings were observed: The first grade MRI image made some tissue considerations harder to detect because of its limited intensity range. Soft tissues and cerebrospinal fluids as well as other parts of the body had contrast limitation which reduced diagnostic clarity. While preserving structure, Linear Contrast Stretching (LCS) pixel intensity values globally enhanced the contrast of the image. With stronger highlighting of some anatomical features without overexposure, Bi-Linear Contrast Stretching (BLCS) made control to over intensity regions easier. In addition, visibility with adjustment of the contrast makes important details visible, especially in medical imaging like MRI scans for brain tumors. Clear skies are shown by high SSIM while good contrast is shown. The outlines of images showing bleeding have less noise and high contrast indicating a high PSNR value. While SNR indicates delightful less picture mistake.

TABLE I. Average for Accurate Detection of Brain Tumor

Parameters	**Original**	**CS**	**LCS**	**BLCS**	**CA**
PSNR	40.954	41.0856	40.979	41.487	**42.0799**
SNR	10.7945	16.6756	11.9593	15.644	**20.9691**
SSIM	0.4571	0.5567	0.4896	0.6338	**0.6428**

V. Quality Details

Using some common quality metrics, each of the aforementioned approaches is compared statistically.
a). Structural Similarity Index (SSIM).
b). Peak Signal to Noise Ratio (PSNR).
c). Signal-to-Noise Ratio (SNR).

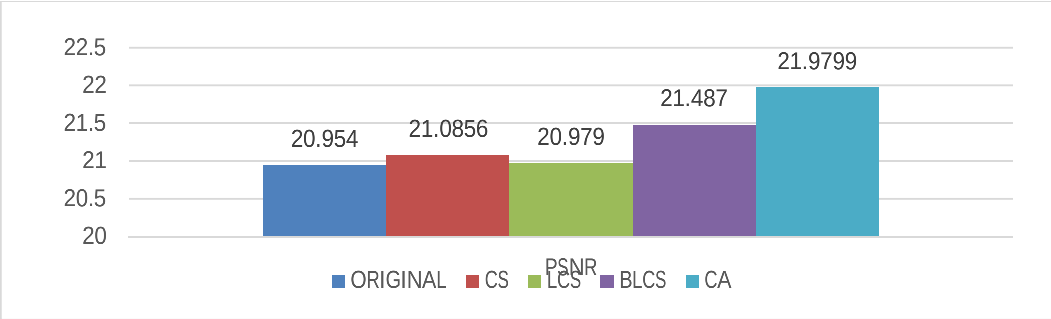


Fig. 6 Graph of PSNR

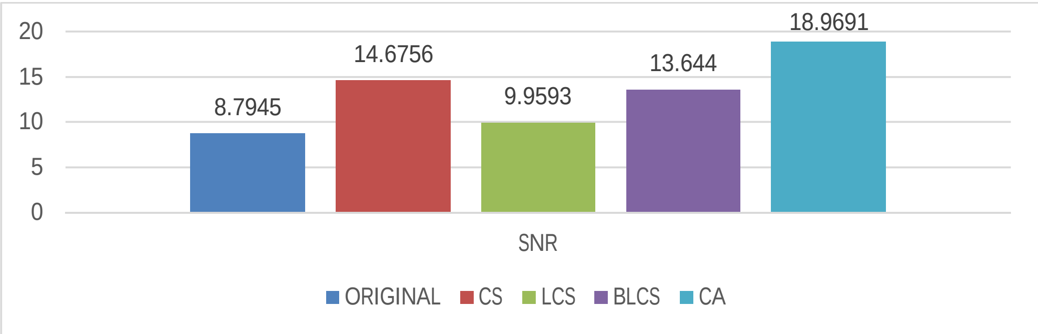


Fig. 7 Graph of SNR

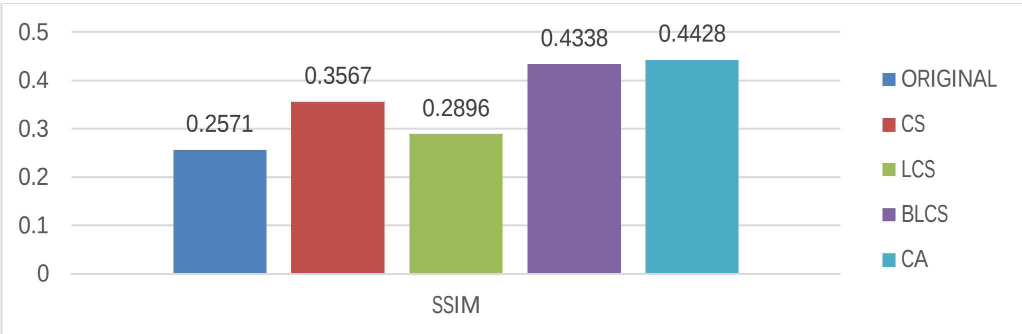


Fig. 8 Graph of SSIM

VI. Conclusion

As a result, the use of contrast enhancement techniques, including contrast stretching (CS), linear contrast stretching (LCS), bi-linear contrast stretching (BLCS) and contrast modification greatly improve to the visualization and diagnostic quality of the MRI image of brain tumor. Using quantitative evaluation using (PSNR), (SNR) and (SSIM), we have shown that these methods enhance picture contrast, making subtle tumor characteristics easier to identify. When it comes to balancing structural fidelity, noise reduction, and contrast enhancement, bi-linear contrast stretching and contrast adjustment have proven to be the most effective techniques. These findings demonstrate the critical role advanced contrast enhancement techniques play in medical imaging, leading to a more accurate and reliable diagnosis of brain tumor.

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