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Enhancement of MRI images of hamstring avulsion injury using histogram based techniques

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Abstract
A novel histogram based image enhancement technique is introduced to visualize the image more effectively. The proposed method uses hamstring avulsion injury Magnetic Resonance Imaging (MRI) images from the database. First, the image is clipped using the histogram. Second, the image is subdivided into eight sub-images and enhanced individually until a better enhancement rate is maintained to obtain the final output of the proposed method. The proposed method shows effective enhancement for clear visualization of the injury. The strength of the proposed method is compared with different histogram based enhancement techniques based on the parameters such as F-measure, Contrast improvement index (CII), Absolute Mean Brightness Error (AMBE) and Peak Signal to Noise Ratio (PSNR) to determine the efficient enhancement technique. The parameters are defined to be significant for different enhancement techniques based on the statistical analysis. Further classification of the enhancement techniques are performed with the help of decision tree classifier. Based on the results of the classifier, the proposed algorithm is stated to be more significant and efficient in enhancing the region of interest in the Hamstring Avulsion Injury MRI images. Thus the proposed method shows effective enhancement for improved visualization of the hamstring injury for the diagnosis of the state of injury. With these results, the region of injury can be analysed effectively for further processing.

Keywords Magnetic resonance imaging · Avulsion injuries · Contrast enhancement · Histogram clipping · Decision tree classifier

1 Introduction

Hamstring is a muscular region which is located in posterior part between hip and knee. There are hamstring muscles in three different areas that are defined as biceps femoris,

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semimembranosus and semitendinosus. Since it is located in the active region, the chance of hamstring injuries is commonly occurring in sportsmen like athletes, soccer players, cricket bowlers, runners, sprinters, long jumpers and so on. The chance of hamstring injury is effective on gymnastic athletes when compared to others sports [9]. Hamstring injuries occur due to the stressed activity of hamstring muscles for a long period of time. Hamstring injury starts from minor pain to a complete muscle tear. A hamstring injury can be classified into three grades. They are mild pain (grade-1), moderate pain (grade-2), severe pain (grade-3). The grades of the hamstring injury can be distinguished clearly through a percentage of lesions or injury in Magnetic Resonance Imaging (MRI) image of hamstring muscle region. The grades are explained in Table 1.

The most severe painful injury comparing all other hamstring injuries is hamstring avulsion injury. This kind of injury comes under grade-3 since hamstring avulsion injury involves complete muscle tear from the tendon or dislocation from the tendon. This injury takes place in the outer region of the hamstring muscles [2, 26, 28]. There are some rare cases which involve muscle tear from the centre part of the hamstring muscles. Hamstring avulsion injury will affect biceps femoris. The symptoms of hamstring avulsion injuries are severe pain, difficulty in bending and straightening of a knee, severe edema, blood clot. Sudden contraction of the hamstring muscles during some exercises such as a sudden long jump and lifting heavy loads without warm-up exercises can cause hamstring tendon avulsion (tendon is a tough bone which joins the muscles and the bones by its bony attachment).

Hamstring avulsion injury occurs rarely due to sudden actions which have been listed above and it's difficult to differentiate that with a simple hamstring strain. Strengthening the hamstring muscle is one effective way to get rid of a hamstring strain. Hamstring strains can be cured through medications and some warm-up exercises but hamstring avulsion injuries need months of rehabilitation programs/treatment to recover the affected region. Although hamstring avulsion injuries can be easily visualised by the experts/physiotherapists, the accurate area of tear can be only analysed through the Magnetic Resonance (MR) imaging.

The histogram is the graphical representation of the picture elements (pixels) of an image [20]. Different enhancement techniques based on histogram have been approached previously such as Histogram equalization, Brightness preserving dynamic histogram equalization, Contrast limited adaptive histogram equalization, Recursive mean separate histogram equalization, Recursive sub-image histogram equalization, exposure-based sub-image histogram equalization and Median mean based sub-image clipped histogram equalization [24]. This technique

Table 1 Difference between the grades of hamstring injuries

Grades of hamstring injuries	Percentage of lesions	Symptoms	Duration of Rehabilitation
Grade-1	Less than 5%	Edema, mild pain, reduction in stretch and contraction of muscles	Can be recovered within a few days based on medications or exercises
Grade-2	Between 5 and 50%	Hemorrhage, difficulty in bending and straightening of knees, sudden/sharp pain at the posterior region of thigh muscles	Can be recovered within 1–3 months based on a rehabilitation program
Grade-3	Greater than 50%	Complete muscle tear causes severe pain	Can take more than a month based on rehabilitation programs

helps in better enhancement of medical images. But the existing techniques have some drawbacks such as over brightness distribution on the overall region and very low brightness on the image causes poor analysis of the obtained images. To overcome these drawbacks, an algorithm is proposed to study the state of the injury and to categorise the grades of injury.

2 Literature review

In this paper, histogram based enhancement is performed for the MRI images of hamstring avulsion injury. Different techniques are defined for the enhancement of MRI images. Chen.G., et.al (2016) describes a denoising filter using non-local means which effectively used for enhancement of MRI images. The method proposed illustrates less blurring effects and high preservation [7]. Chen.G., et.al (2019) defines an algorithm for removing noise in diffusion MRI data using graph Framelet Matching in x-q Space which initiates recurrent process and minimizes the blurring [8].

But the proposed algorithm in the paper concentrates on subdivision of images based on histogram. Therefore histogram based existing techniques are compared with the proposed algorithm to describe the efficient technique of hamstring avulsion injury. Kuldeep Singh., et.al (2014) proposed a novel histogram based image enhancement technique which performs clipping operation in the given image [17]. The comparison between six existing enhancement techniques based on histogram such as histogram equalization(HE), brightness preserving bi-histogram equalization(BBHE), minimum mean brightness error bi-histogram equalization(MMBEBHE), dualistic sub image histogram equalization(DSIHE), recursive sub image histogram equalization(RSIHE) recursive mean separate histogram equalization(RMSHE) was done to show the effective characteristic of image quality and improved visualization. The output of this proposed method (ESIHE) can be obtained from the following procedure. First, the histogram of the original image is obtained. Second, the exposure rate is calculated and a threshold value Third the image is clipped into two sub-images based on the different intensity levels by giving a threshold value and the histogram of these subdivided images are obtained. Then histogram equalization is applied until a better contrast rate is maintained in every image. Finally, the images are integrated into a single image. Hence the output of the proposed system is obtained. In this paper, they have used images such as fish, hands, tank and cat. To analyse the effectiveness of the output image of the proposed method, entropy was calculated for every output image of the proposed method. ESIHE preserves the image from getting over bright and shows effective visualization.

K. S. Sim., et.al (2007) introduced a method to overcome the drawbacks of the histogram equalization and other histogram based image enhancement techniques such as bi-histogram equalization (BHE) and recursive mean separate histogram equalization (RMSHE) [23]. The methodology of BHE and the recursive mean separate histogram equalization are studied. Were BHE divides the input image into two sub-images and performs equalization independently [13, 25]. RSIHE performs better enhancement comparing both the HE and BHE. The mean separation for enhancement is done once in BHE. But RMSHE performs repeated mean separation on the input image to achieve more brightness preservation. In recursive sub-image histogram equalization performs the average brightness for the segmented gray level and middle-level region of the grayscale images are obtained.

Kuldeep Singh., et.al (2014) defines a method which is similar to the previous method, Exposure-based Sub Image Histogram Equalization (ESIHE). In ESIHE the images are subdivided into two and clipped to obtain better visualization [6, 12]. In this paper the author calculated both mean and median rate and histogram clipping is done using plateau limit. Then the image is sub dived into four based on individual intensity levels. After maintaining the enhancement rate the images are integrated into a single image (output image). The obtained image improves the brightness of the foreground image by reducing the brightness of the background. Thus better visualization is obtained.

In the proposed method, histogram clipping is performed by sub-dividing image into eight different sections with the help of the histogram threshold limit defined to determine the histogram bins of greater values. The subdivision of the images occurs at different intensity levels. The threshold rate is changed simultaneously until an effective enhancement rate is obtained. Then the sub-divided images are integrated into a single image. After integration of the sub images, the background region gets diminished with the enhancement of the region of interest based on the variations in intensity range. The effectiveness of the proposed method is determined by comparing the method with previous stated techniques through different parameters such as F-measure, Absolute Mean brightness error, contrast improvement index and PSNR. The significant nature of the parameters is analysed using statistical analysis. Further the efficient enhancement technique is defined using the process of classification using decision tree. With the results of the classifier, the proposed method is determined to be more efficient in enhancement of the avulsion injury region compared to all other techniques.

3 Methodology

Histogram equalization based enhancement techniques perform over brightness or sometimes it distributes very less brightness on the input image. To overcome this drawback the proposed method is introduced. The proposed method is basically similar to the histogram based enhancement techniques such as RSIHE, ESIHE, MMSICHE in which histogram clipping and subdivision of images are performed. The subdivided images are integrated using adaptive neighbourhood pixel distance and intensity variations. With this algorithm, the background pixels gets diminished. The region of injury can be defined more accurately by subtracting the input image with the integrated clipped image. The efficiency of the proposed method is analysed using parameters like F-measure, AMBE, CII and PSNR. These results are compared with all existing methods of histogram enhancement techniques. The significant nature of the parameters is analysed using statistical techniques such as Rank test and standard error. The proposed method is determined to be more efficient with the help of the decision tree classifier. Region of characteristics of the classifier defines that the proposed method is more significant in describing the region of injury which can be analysed for diagnosis of grades in MRI images of hamstring avulsion injury.

The input images considered for the study is derived from a standard database, RADIOPEDIA. Different images from different modalities are available which includes CT, MRI and ultrasound images. This database mainly possesses case studies with radiological images that can used for further analysis The database consist of more than 30,000 radiological case studies with results for study purpose [22]. These images are used in various applications.

3.1 Histogram-based equalization techniques

3.1.1 Histogram equalization (HE)

HE is a traditional histogram defined contrast enhancement technique [4, 11]. HE provides intensity distribution and improves the contrast by stretching the dynamic range. The drawbacks of HE is it does not prevent brightness, instead it gives more brightness to the image.

$$s_k = \sum_{j-=0}^{k} p_r(r_j) \tag{1}$$

Equation (1) describes s_k as the discrete approximation of the transformation functions of histogram equalization and $p_r(r_j)$ as the probability distribution of the pixels based on histogram.

3.1.2 Brightness preserving dynamic histogram equalization (BPDHE)

To overcome the over brightness distribution on the image, a novel technique called Brightness preserving dynamic histogram equalization (BPDHE) was introduced [18]. BPDHE is the extension of HE. The mean intensity of the input and output image is more or less similar. This makes the image to maintain mean brightness. The cons of BPDHE are it preserves over brightness which makes the image to result with low intensity.

$$g(x, y) = M_i/M_o \ f(x, y) \tag{2}$$

where, f(x,y) and g(x,y) as the input and final output of the BPDHE shown in the eq. (2) with M_i and M_o as the Mean input and output pixel distribution.

3.1.3 Recursive mean separate histogram equalization

RMSHE is the generalized version of brightness preserving bi-histogram equalization (BBHE). RMSHE provides scalable brightness to the image were the mean brightness of both input and output will be the same [19].

$$E(Y) = Xm + [(XG–Xm)/2 n] \tag{3}$$

Equation (3) indicates that as level of recursion becomes larger, the output will converge to the mean of the input X_m. This provides the method, degree of brightness (XG) preservation range from 0% (output of HE) - 100% (back the original image).

3.1.4 Contrast limited adaptive histogram equalization (CLAHE)

CLAHE is a contrast enhancement technique that works on smaller regions of an image [1, 5, 21, 27]. The histogram of contrast images matches the histogram of output contrast level by a specified or limited distribution. The contrast spreads in all the region of the image thus equalizes the intensity of the image and results in poor identification of the required region.

3.1.5 Exposure based sub-image histogram equalization (ESIHE)

ESIHE is one of the effective enhancement technique that performs clipping operations. ESIHE subdivides the image into two and performs enhancement on the individual image until an effective enhancement rate is obtained [14, 29]. Finally, the enhanced images are integrated into a single image and results in improved visualization. It can be expressed as Eq. (4) & (5).

$$F_L = X_a * C_L \tag{4}$$

$$F_u = (X_a + 1) + (\mathrm{L} - X_a + 1) C_a \tag{5}$$

F_L and F_u are the transfer functions used for equalizing the sub histograms individually. Were X_a is related to exposure rate, L is the total number of gray levels, C_L and C_a are the corresponding cumulative distribution function (CDF) of the individual sub-images The final step involves the integration of both sub-images into one complete image.

3.1.6 Recursive sub-image histogram equalization (RSIHE)

RSIHE preserves the energy and offers better contrast to the overall region of the image and makes the resulting image to acquire the required region along with better visualization**.** The transfer function f_L(w) using the CDF function is expressed in Eq. (6) and (7).

$$f_L(\mathrm{w}) = W_0 + (W_{L-} W_0) CDF_L(\mathrm{w}) \tag{6}$$

$$f_U(w) = W_{m+1} + (W_{L-1} - W_{m+1}) CDF_U(w) \tag{7}$$

f_L(w) and f_U(w) are the equation of RSIHE for two sub-divided images. W_{m+1} is the total number of pixels with gray-level and the $W_{L-1}$is the decomposed image final step is to integrate these two-subdivided images.

3.1.7 Median mean based sub-image clipped histogram equalization (MMSICHE)

MMSICHE is similar enhancement technique like ESIHE. The histogram clipping is done based on the mean and median value and the enhancement is performed on four sub-images. The enhanced images are integrated into a single image which improves the effective analysis of the required region of the input image. Although MMSICHE shows effective enhancement and visualization, the grayscale variation can be converted into the proposed method. The proposed method shows an accurate analysis of the required region.

$$F_{Ll} = X_{ml} + C_{Li} \tag{8}$$

$$F_{Lu} = (X_{ml} + 1) + (X_e - X_{ml} + 1) * C_{Lu} \tag{9}$$

$$F_{Ul} = (X_e + 1) + (X_{ml} - X_e + 1) * C_{Ul} \tag{10}$$

$$F_{Uu} = (X_{mu} + 1) + (L - X_{mu} + 1) * C_{Uu} \tag{11}$$

F_{Ll}, F_{Lu}, F_{Ul} and F_{Uu} are the overall equations for sub-dividing the images into four. Finally, the images are integrated into a single image (output image).

3.2 Histogram clipping

When histogram equalization is performed on the original image, the contrast of higher histogram region is stretched and the contrast of lower histogram region in compressed [4]. It distributes equalised brightness over the image which results in improved brightness. HE has no rate of boundary/limit to distribute specified brightness over the required region. So the enhancement rate is affected. Clipped histogram overcomes this drawback of unnecessary brightness distribution. Threshold values are specified which limits the unnecessary distribution of brightness over the image. Equation (12) given below determines to limit factor for enhancement rate.

$$\frac{d}{dx} c(x) = p(x) \tag{12}$$

In the eq. 12, p(x) describes the probability of the pixels in histogram. The setting for threshold rate is maintained and this allows the preservation of over distribution of enhancement in an image.

3.3 Proposed method

The proposed method basically works on the principal of clipped histogram technique. In existing techniques such as ESIHE and MMSICHE, the images are clipped based on the threshold values and enhancement rate is analysed to obtain the output images. The proposed method is similar to those techniques in which ESIHE clips the images into two sub-images and MMSICHE clips the images into four sub-images. When the subdivision of the images increases, the finer intensity details can be analysed and enhanced. Each subdivision of the image categorises the pixel variations in the entire image. Therefore, in the proposed algorithm, the number of subdivided images are increased to enhance the MRI images of the hamstring avulsion injury.

The proposed system performs the enhancement rate with eight subdivided images as shown in Fig. 1. Before subdividing the images, histogram threshold limit or clipped histogram limit is specified to illustrate the histogram bins having greater values than the threshold value and should not cross the limit. The images are clipped into eight sub-images with different intensity values. Threshold value depends on the intensity levels of the images. The threshold rate is changed simultaneously until an effective enhancement rate is obtained. The histogram of all the subdivided images is obtained to differentiate the histogram plot. Then the subdivided images are integrated into a single image. The process of integration is illustrated by describing the neighbourhood pixel distance with respect to the intensity variations that

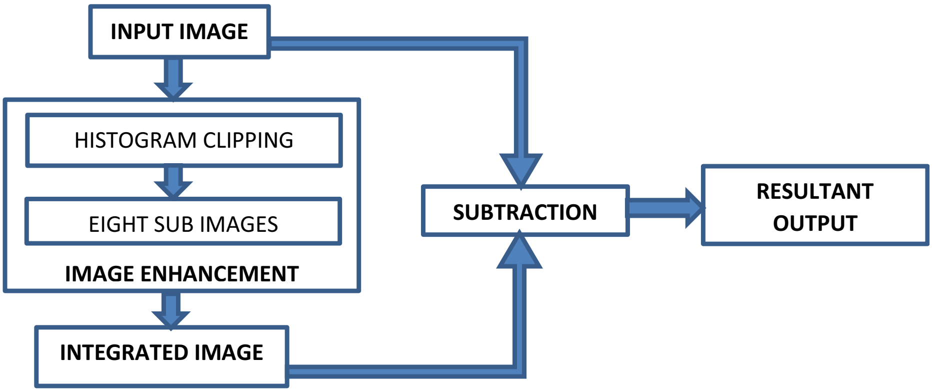

Fig. 1 Block diagram of the proposed method

describes the histogram clipping. The pixel distance between the neighbours is defined in such a way that the changes in the intensity levels in the subdivided MRI images are studied. The blocks of images are integrated adaptively depending on the pixel distance value correlation with the neighbourhood pixels. Thus appropriate matching and integration of the subdivided images are described to produce efficient result, enhancing the MRI hamstring avulsion injury images. The integrated images of the ESIHE and MMSICHE show the possible visualization of foreground and background region respectively. While performing the eight sub-image integration, the background region gets supressed due to the intensity variations. Since the intensity range is based on the histogram, the high intensity regions gets enhanced in higher rate reducing the background pixels. The required region can be defined clearly by subtracting the original image with the resultant image for enhanced high intensity regions. Thus the injury region in the MRI image are enhanced effectively using the proposed algorithm based on histogram clipping.

3.4 Parameters

The proposed enhancement method based on histogram clipping is performed to determine the region of injury in the Hamstring avulsion images. The efficiency of the technique proposed is defined by deriving certain image quality parameters like F-measure, Absolute Mean Brightness Error, Contrast Improvement Index and Peak signal to Noise Ratio. These parameters are obtained for all the existing techniques and the proposed method and compared. Statistical Analysis of the image quality parameters are carried to define the significant nature of the parameters.

3.4.1 F-measure

F-measure defines the performance accuracy of the test in which the primary factor is precision and recall. These parameters describe the accurate nature of the test. F-measure for the enhancement techniques are defined using the recall and precision values [16]. For F-measure determination, the images are converted into binary images for mapping. F- measure is described below in the eq. (13).

$$F\text{−}measure = 2.\frac{Precision.Recall}{Precision + Recall} \tag{13}$$

3.4.2 Absolute mean brightness error

AMBE calculates the rate of brightness that is preserved from the original image to the proposed output image [11]. AMBE can be obtained by subtracting the mean value of the output image with the mean value of the input image. AMBE can be expressed as the mean difference between input and output image. Smaller AMBE value denotes effective brightness preservation.

$$\mathrm{AMBE} = |\mathrm{E(X)}-\mathrm{E(Y)}| \tag{14}$$

Where E(X) is the mean of the output image and E(Y) is the mean of the input image is shown in eq. (14).

3.4.3 Contrast improvement index

Contrast improvement index (CII) measures the ratio of local contrast of output image with the input image. Here the contrast refers to the mean values of the images. CII stands as a benchmark for all the enhancement techniques for its satisfying result to understand the effectiveness of the output image. Larger CII values indicate greater effectiveness of the obtained image comparing the existing techniques. Contrast improvement index is expressed below in the eq. (15). If the CII value of output image is then the mean value of the input image, it indicates the improvement of contrast.

$$\mathrm{CII} = \frac{\text{Contrast of the proposed image}}{\text{contrast of the input image}} \tag{15}$$

3.4.4 Peak signal to noise ratio (PSNR)

Peak signal to noise Ratio (PSNR) is mainly to define the ratio between the maximum power of a corrupted noise and power of the original image that causes damage to the fidelity. PSNR is expressed in terms of logarithmic decibels. In image processing, PSNR is used to measure the quality of the image after processing especially after reconstruction and enhancement. Peak signal to noise ratio is de-scribed in the eq. (16).

$$\mathrm{PSNR} = 10 \times \log\left(\frac{255^2}{MSE}\right) \tag{16}$$

The image quality parameters are obtained for both the existing histogram based image enhancement techniques and the proposed and compared. The effective nature of the enhancement techniques is defined by these parameters. Significant nature of the parameters is analysed using statistical techniques. Further classification of the histogram based enhancement techniques is performed to analyse the efficient technique for identification of the region of injury in hamstring avulsion injury MRI images.

3.4.5 Statistical analysis

Statistical Analysis is performed to determine the significant nature of the parameters derived from the different enhancement techniques based on histogram. The statistical features like average mean and standard error are defined for the image quality parameters. These features define the significant nature of the types of enhancement techniques [10].

Mean Mean is defined as the average value obtained by computing the sum of all outcomes divided by the overall values. Mean value is illustrated below in the eq. (17) in which n is the sample size and x is observed value.

$$\text{Mean}, \overline{x} = \frac{1}{n}\sum_{i=1}^{n} x \tag{17}$$

Standard error Standard error can be termed as measurement of prediction accuracy. Estimated standard error (σ_{est}) is related to sum of squared deviations of prediction (that is sum of squares error) which is defined in the eq. (18) below where Y is an actual range, Y′ is a predicted range, N is the number of pairs of scores. $\sum(Y-Y')^2$ is the sum of squared differences between the actual scores and the predicted scores.

$$\sigma_{est} = \sqrt{\frac{\sum\left(Y-Y'\right)^2}{N}} \tag{18}$$

After determining the significant nature of the parameters, they are classified using decision tree classifier. The classifier results define the efficient enhancement technique for identification of the region hamstring avulsion injury in MRI images.

3.5 Classification

The different enhancement techniques are classified with the proposed method based on the image quality parameters. Decision tree classifier is used for the process of identification of the efficient enhancement technique. Decision tree classifiers are part of machine learning that describes the state of the sample data. Trees are graphical representation of the responses and decisions through a node that branches to many leaflets (classes). Decision trees can be defined as classification trees are used to predict the data responses based on the sample classes. Prediction of a response is followed by the decisions of the tree which starts from the root of the data (beginning) to the leaf nodes. These leaf nodes possess the response of the data. Classification trees normally respond in true or false that is nominal. Multiple splitting and branching are possible with the help of the sample data's considered for the process of classification [3].

In this method, the existing enhancement techniques and proposed methods are classified based on the quality parameters. The efficient technique for the enhancing the region of injury is defined based on the classifier results. Confusion matrix defines the state of true and false conditions of the enhancement techniques. Region of Characteristics curve also describes the efficiency of the classifier and defines the proposed method to be more efficient in enhancing the hamstring avulsion injury in MRI images. The architecture of the decision tree classifier is defined below in the fig. 2 which describes the decision and leaf nodes for the analysis of the responses. Primary Decision node defines subdivided decision and primary leaf node illustrating the response as stated in target unit used for training. Histogram equalization (HE) is defined as the primary leaf node and the proposed method to be the end leaf node for Decision tree classifier used in this study. The subdivision of the decision and leaf nodes occurs based on the target unit used for training.

4 Results and discussion

The proposed method is a novel approach which overcomes all the drawbacks of the previous histogram based image enhancement techniques such as HE, BPDHE, RMSHE, CLAHE, RSIHE, ESIHE, MMSICHE. This method effectively preserves the over brightness of required region in the foreground but the background region is shown with effective brightness for accurate analysis and unnecessary energy distribution over the required region is also preserved. Images of Magnetic resonance imaging of the hamstring avulsion injury are considered as the input image which was derived from the database called RADIOPEDIA. The database image are analysed with different enhancement techniques based on histogram to increase the intensity and to configure a prominent appearance to the region of injury in the MRI image. The algorithm proposed involve histogram clipping to subdivide the image into eight sub divisions that preserves the intensities of high range. The outputs obtained from the existing histogram based enhancement techniques have been listed below in Fig. 3.

The proposed method which involves histogram clipping, subdividing and integrating defines the effective visualisation of the region of injury that describes the state of injury based on which grading is performed. The output of the proposed method with high efficiency is shown in Fig. 4.

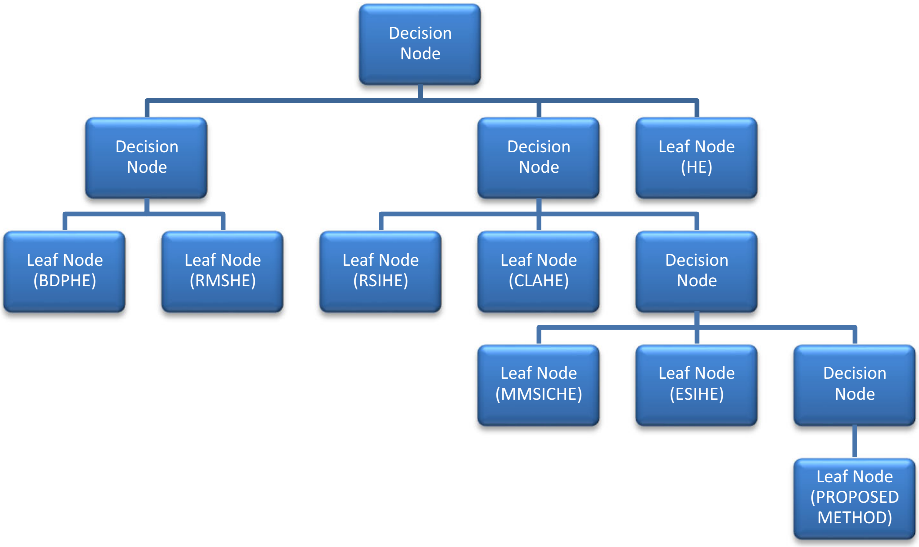

Fig. 2 Architecture of decision tree classifier

Fig. 3 Results of the existing histogram techniques

Fig. 4 Result of the proposed output

F-measure, Absolute Mean Brightness error, Contrast improvement index and Peak signal to noise ratio for the existing enhancement histogram techniques and the proposed method. These image quality parameters are used for analysing the efficient technique for enhancing the injury regions in MRI images. This improvement is the evidence of improvement of enhancement in the obtained image. Thus, the proposed method satisfies all the parameters and proves to be an effective histogram based enhancement technique for analysing the area of interest. In the method, Table 2 clearly specifies the calculated values of the different enhancement techniques.

In this method, graphical representation of the average values of the image quality parameters like F-measure, AMBE, CII and PSNR are defined. The proposed method is described to be more efficient for defining the region of injury in MRI images. In the fig. 5, F-measure, AMBE, CII and PSNR are defined to be high for the proposed method when compared with all the existing techniques. The image quality parameters describes that the enhancement technique helps to enhance the region of interest without drawbacks of over brightness.

After deriving the parameters, statistical analysis is performed to test the significant nature of the parameters. Statistical features like Average mean and standard error of the parameters are obtained to define the significance among the enhancement techniques. These metrics or parameters describe the efficient technique for the enhancement of the region of Hamstring injury. The average mean and standard error values in the Table 3 define the nature of the parameters derived from the enhancement techniques.

The significant nature of the parameters is analysed using statistical features. Further, these metrics undergo the process of classification that classifies the different enhancement and illustrates that the output of the proposed method is more efficient and effective to describe the injury region. In this classification process, decision tree classifier is used in which the data's are trained based on the nominal true or false condition. After training, validation and testing of the data occurs. True positive, true negative, false positive and false negative segregation of the images based on the parameters derived from the histogram based enhancement techniques is defined accurately with the help of the confusion matrix. Confusion matrix describes rate of misclassification or accurate nature of the classifier to differentiate the different enhancement techniques. Confusion matrix is defined in the Table 4 in which the different techniques are illustrated and compared with the proposed technique. Accuracy, precision, specificity and sensitivity are described based on the true positive, true negative, false positive and false negative conditions of the enhancement techniques. From the confusion matrix, the proposed method is illustrated to be more efficient with 100% accuracy.

Table 2 Comparison of results obtained from the parameters of histogram-based enhancement techniques

HISTOGRAM ENHANCEMENT TECHNIQUES	F-MEASURE	AMBE	CII	PSNR
HE	0.0172	94.75	2.8750	30.12
CLAHE	0.0229	103.01	3.0017	32.78
MMSICHE	0.0772	117.08	3.2151	34.98
ESIHE	0.1772	144.80	3.3596	35.02
BPDHE	0.2763	153.02	4.9993	35.89
RMSHE	0.4576	163.54	5.1089	36.45
RSIHE	0.6342	175.82	6.3601	36.90
PROPOSED METHOD	**0.7892**	**181.79**	**6.9163**	**38.02**

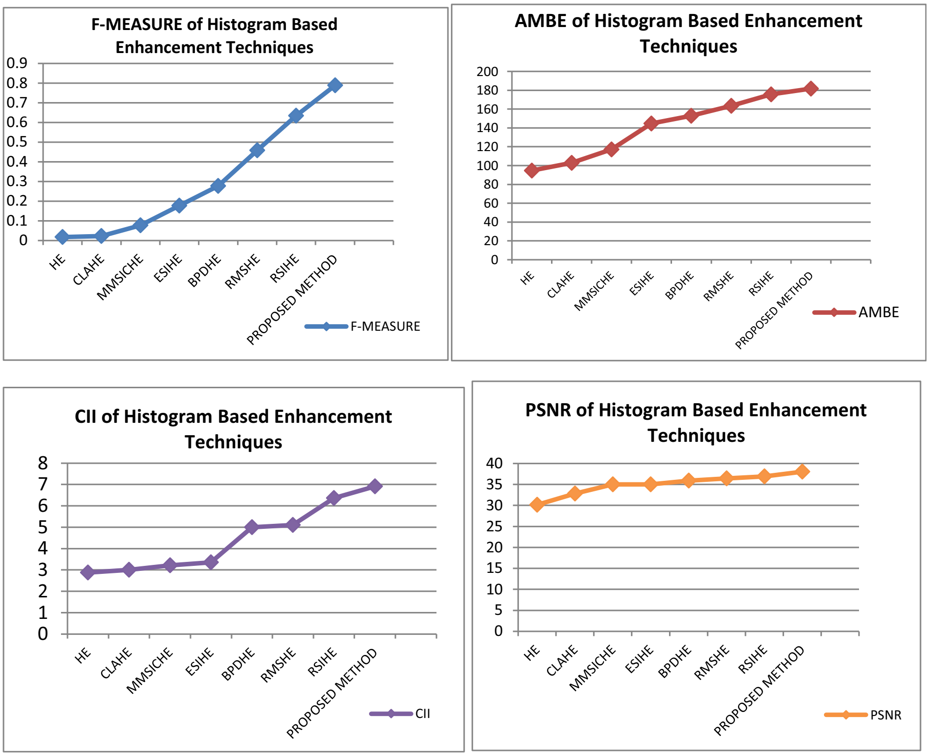

Fig. 5 Graphical representation of the image quality parameters

Region of characteristics curve is used to determine the efficiency of the classifier to differentiate the classes provided to it as input. Based on the area under the curve, classification efficiency of the classifier is described. Graphical Representation of Area under the curve of Region of characteristics (ROC) curve for the Decision tree classifier is defined below in fig. 6.

With these results, the proposed method is efficient and significant that can be used for the enhancement of the avulsion injuries in MRI Images. This proposed enhancement technique defines the injury more appropriate for further image processing and to determine the state and grade of the injury. Thus automatic system can be developed for the diagnosis of the stages of injury.

5 Conclusion

In this method, an algorithm for enhancement based on the histogram is defined. Input images are derived from the database RADIOPAEDIA. Histogram-based image enhancement technique is performed using histogram clipping. In some cases of image enhancement, the histogram equalization distributes effective brightness over the unnecessary region of the image. A histogram threshold or histogram clipped value is maintained or specified to overcome the unwanted brightness distribution in the image. The images are subdivided into eight images based on the intensities without crossing the threshold limit. The images are defined with better satisfying enhancement rate. This result is enhancing the area of interest

Table 3 Statistical features of the Parameters of the histogram based enhancement techniques

Histogram based enhancement techniques	Average Mean			Standard Error				
	F-measure	AMBE	CII	PSNR	F-measure	AMBE	CII	PSNR
HE	0.0171+_0.03	33.18+_0.04	2.8750 +_0.03	30.12 +_0.03	0.0091+_0.03	30.79+_0.060	2.8751+_0.04	0.256+_0.02
CLAHE	0.0229+_0.07	35.31+_0.04	3.0017+_0.06	32.78 +_0.13	0.0129+_0.05	33.84+_0.150	2.0018+_0.07	0.356+_0.06
MMSICHE	0.0778+_0.03	40.08+_0.04	3.2151+_0.03	34.98+_0.05	0.0378+_0.03	38.50+_0.050	2.2151+_0.03	0.423+_0.03
ESIHE	0.1772+_0.02	49.70+_0.04	3.3596+_0.08	35.02+_0.11	0.0772+_0.04	47.55+_0.005	2.3596+_0.02	0.489+_0.08
BPDHE	0.2778+_0.07	52.65+_0.04	4.9993+_0.06	35.89+_0.04	0.0978+_0.07	50.18+_0.160	2.9993+_0.20	0.562+_0.10
RMSHE	0.4756+_0.05	56.21+_0.04	5.1089+_0.03	36.45+_0.09	0.1756+_0.05	53.67+_0.010	3.1089+_0.15	0.782+_0.04
RSIHE	0.6342+_0.09	60.72+_0.04	6.3601+_0.02	36.90+_0.11	0.2342+_0.04	57.56+_0.008	3.3602+_0.21	0.823+_0.02
PROPOSED METHOD	0.7892+_0.01	63.10+_0.04	6.9163+_0.03	38.02+_0.16	0.4892+_0.01	59.36+_0.110	3.5163+_0.01	0.911+_0.10

Table 4 Confusion matrix of the comparison of the techniques

	HE	CLAHE	MMSICHE	ESIHE	BPDHE	RMSHE	RSIHE	PROPOSED METHOD
Accuracy (%)	92	96	94	90	91	97	98	100
Precision	0.92	0.96	0.94	0.90	0.91	0.97	0.98	0.98
Specificity	0.92	0.95	0.93	0.91	0.92	0.96	0.97	0.99
Sensitivity	0.89	0.96	0.94	0.90	0.91	0.97	0.96	0.99

only. It enhances only foreground region by darkening the background region. Xin Liao (2018) describes an adaptive data hiding technique to preserve the discrete cosine transform (DCT) coefficients of the image depending on the DCT block dependencies [15]. The process of integration in the proposed algorithm mainly depends on the neighbourhood distance based on the intensity. The required region can be defined clearly by subtracting the original image with the resultant image for enhanced high intensity regions. Thus the injury region in the MRI image are enhanced effectively using the proposed algorithm based on histogram clipping. To examine the effectiveness of the resultant image some parameters are calculated. They are F-measure, Absolute Mean Brightness Error (AMBE), Contrast Improvement Index (CII) and Peak Signal to Noise Ratio (PSNR). The significant nature of the parameters derived is obtained through statistical analysis. Average mean and standard error are the statistical features used to describe the significant nature of the image quality parameters. Further, decision tree classifier is used for the identification of the efficient technique of enhancement. Thus the comparison of parameter values between both the proposed technique and the existing histogram based enhancement techniques is analysed and proves that the effective enhancement is obtained in the proposed output image. With this technique proposed the injury region is made visible more effectively. This helps in analysing the stages of injury by further processing.

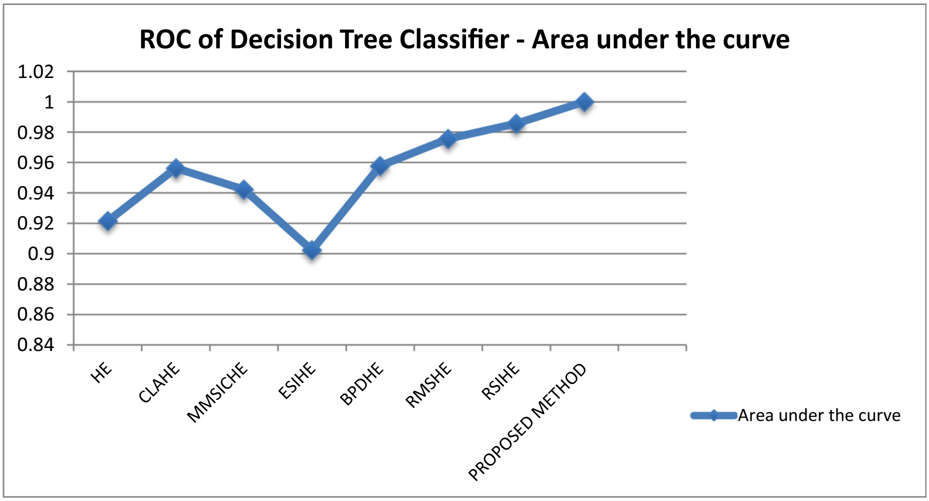

Fig. 6 Graphical Representation of the area under the curve in ROC of Decision tree classifier

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