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Brain Image Enhancement - A Survey

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Abstract: Brain image enhancement, Examination, Conception and investigation permit measurable exploration and conception of medical images of various modalities such as MEG, EEG, PET, MRI, CT or microscopy, to name a few. The basic purpose of enhancement operation is to analyze the brain images precisely in order to effectively diagnose and examine the diseases and problems. Brain imaging is a subfield of medical image processing. The field basically deals with handling the functions and actions taken in the brain. Brain imaging provides a way to investigate and determine brain related diseases in an efficient and effective manner. Enhancement of brain images is a vast field in dealing with these images. The basic objective of this study is to evaluate and discuss different techniques and approaches proposed in order to handle different brain imaging types. The paper provides a short overview of different methods presented in the prospect of brain image enhancement.

Key words: Image · Brain · Analysis · Precision · Medical Imaging · Diseases · Methods

INTRODUCTION

Medical imaging is enduring an upheaval in the earlier period by the arrival of quicker, more precise and a lesser amount of enveloping devices. Medical imaging is one of our mass controlling apparatus for having insight in usual and pathological procedures that influence healthiness. The function of image dealing in medicines is escalating by growing significance of looking out ways to get better workflow in understanding surroundings where additional images are being obtained in gaining more modalities. All the work that has been done in this field drives the necessity aimed at conforming software expansion that in seizure has delivered a chief incentive on behalf of fresh procedures in signal image processing.

Now if we talk about the basic work that has been done in this field, we can say that the most significant part of apparatus in today's medical progress surroundings comprise a list of methods and techniques. The main work and methods [1] followed in medical image processing can be analyzed in Figure 1:

The basic purpose and theme of medical image processing is to diagnose and examine medical images in a more effective, accurate and efficient manner.

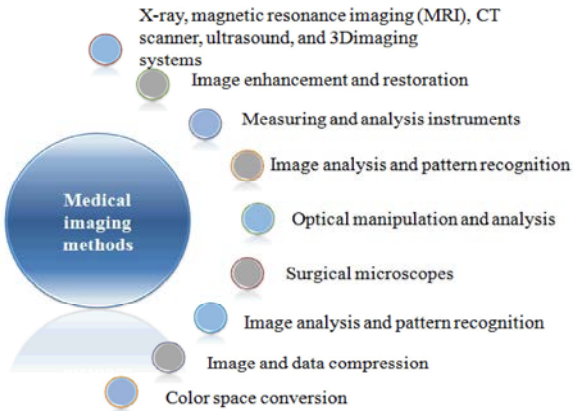

Fig. 1: Medical imaging methods [2]

This objective can be obtained through the process of image enhancement [3]. The images being handled through image processing contain a variety of problems [4] which are listed in Figure 2:

These problems make the image imperfect for accurate diagnose of disease. While handling these problems, our focus is on four main components which are localization, targeting, monitoring and control.

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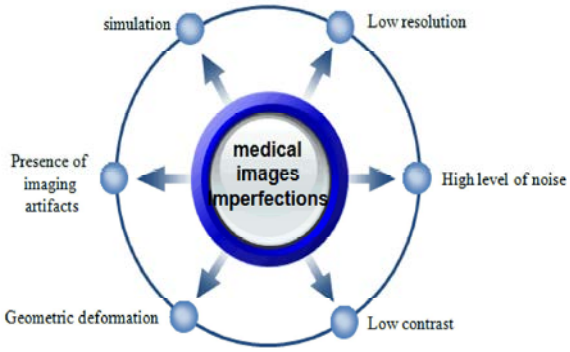

Fig. 2: Imperfections in medical images [6]

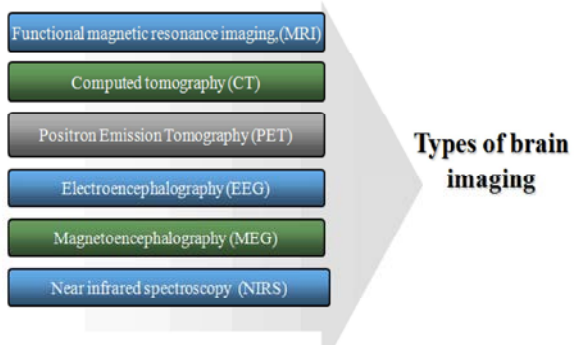

Fig. 3: Types of brain imaging [51]

When we talk about brain diseases that can be handled through medical imaging, there are an accepted figure of approved and protected imaging methods and procedures in exercise today in research services and hospitals all through the world. The techniques [5] are applicable on the brain types mentioned in Figure 3.

Functional Magnetic Resonance Imaging (FMRI): To quantify the actions of brain FMRI is used. MRI utilizes magnetic fields and radio waves to generate premium and improved value two or three dimensional images of brain's organization and construction details devoid of infusing radioactive tracers. MRI [7] is similar to an X-ray; passes within a massive doughnut magnet. It occupies incredibly quick examination of brain to observe which regions of the brain turn out to stimulate and trigger. Using MRI, scientists are able to image equally exterior and profound brain arrangement and construction by means of a high level of anatomical aspect and they are capable to identify minute amendments in these arrangements taking place with the passage of time.

Computed Tomography (CT): CT is basically examining an image of the brain based on the degree of difference inclusion of X-rays. In the process of CT examination, the issue being handled is situated on a board that moves smoothly in and out of empty and vacant cylindrical equipment. The X-ray foundation traverses on a ring in the region within a tube by means of its beam intended at the matter's top. Subsequent to fleeting in the course of subject's top, the beam is illustrated via anyone of the detectors which stripe the perimeter of machine.

Preparation of images by means of X-rays relies on the inclusion of stream of light through the tissue it surpasses all the way through. Consequently, CT examination discloses the repulsive features of the brain but does not determine its construction and arrangement in a good and effective way.

Electroencephalography (EEG): EEG is the measurement of electrical actions and brain movements by means of electrodes positioned on the scalp. EEG is capable of finding out the power, potency and location of electrical doings in diverse brain areas. Scientists are able to find out brain regions and patterns of actions that stain these happenings and occurrences.

Positron Emission Tomography (PET): PET was the initial examination technique to provide functional knowledge regarding the brain. PET and FMRI equally give knowledge regarding neural actions and movements in diverse brain areas as pointed through the level of intellectual blood stream. In this case the functional processes are mapped by means of radioactive substance. In order to identify its working, a special detector is used which is capable of detecting the emitted positron. If we talk about its basic working then we can say that it mainly measures blood stream by initially inserting people through radioactive water and noticing and examining modificationin radiation.

Magneto Encephalography (MEG): MEG basically examines the working carried out in the brain tremendously rapidly - each 1/1000 of a second. MEG is an extremely diverse brain examining procedure. It is strongly connected to electroencephalography as both EEG and MEG basically attempt to determine the identical current of neuronal.

Near Infrared Spectroscopy (NIRS): In order to measure blood oxygenation in the brain, the process of NIRS is used by making use of infrared light to achieve the purpose. This is done by means of spotting light close to the infrared section in the spectrum. In this case the light is spotted by means of skull so that the attenuated amount of light can be detected.

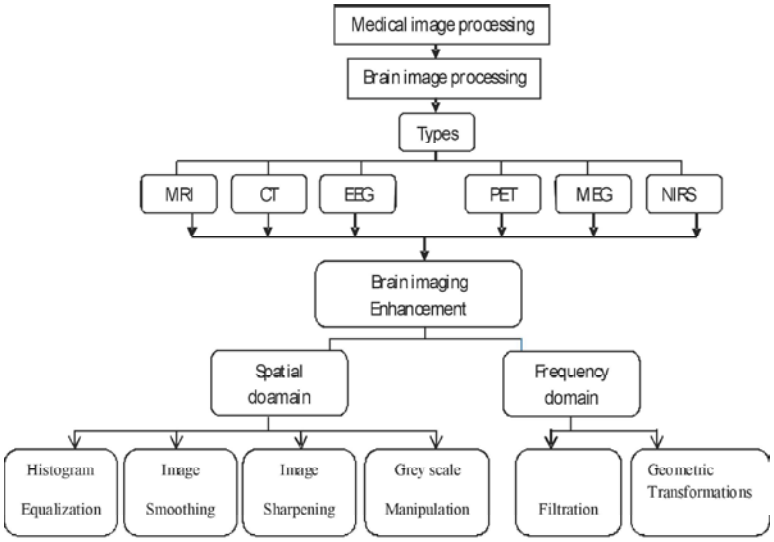

Fig. 4: Brain imaging methods hierarchy

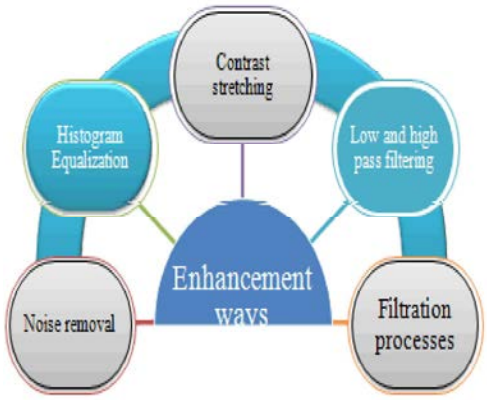

Fig. 5: Brain image enhancement methods

The brain image enhancement is accomplished by utilization of the processes described and proposed in this field. Now as the brain images are used to classify different types of diseases, there exist a number of methods and techniques to achieve the desired purpose in the prospect of brain image processing. These methods are mentioned in Figure 4:

Brain Images Enhancement: Image enhancement [8] is a vast field in digital image processing. The process of image enhancement [9] basically improves the quality of a digital image which has low awareness concerning the basis of degradation. There exist a huge number of techniques and methods that are utilized to improve the image quality.

In general image can be enhanced by applying operations mentioned in Figure 5:

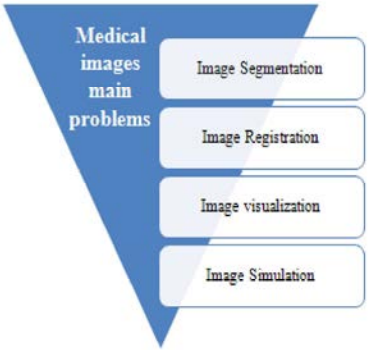

Fig. 6: Main problems in medical images

Noise Reduction: It is a process of removing the noise factor from the digital image. Prior knowledge about the type of noise can help to choose the type of operations to be performed.

Histogram Equalization: This is the process of equalizing all the grey levels in a digital image. The purpose is to equally utilize all the available grey levels present in the image.

Contrast Stretching: This process basically improves the contrast in an image by stretching range of intensity values it encloses with the purpose to cover a desired variety of values.

Low and High Pass Filtration Processes: These processes basically manage the desired range of frequency. Low pass removes the high term frequency and high pass filter removes low frequencies.

While dealing with digital images in view of enhancement, we have four main methods to be considered which are given in Figure 6:

Image Segmentation: Segmentation [10] is a method of partitioning a digital image into several segments. The purpose of segmentation is to make simpler or change the demonstration of an image in notable form that is more significant and easy to examine.

Image Registration: It is the procedure of aligning and arranging two or more descriptions of an identical prospect or vision.

Image Visualization: Visualization is a method of generating an image for the purpose of endorses communication.

Image Simulation: Image simulation is a process of imitation or enactment, as of something like in testing processes.

Now we will have an overview and discussion on the methods proposed in enhancement category of brain imaging process. There exists a variety of work that has been done in brain image enhancement category. Here we will have a look at procedures of each brain imaging type i.e., MRI, CT, EEG, PET, MEG.

Computed Tomography (CT) Image Enhancement Techniques: The technique proposed in [11] is for enhancement of CT brain images by using the concept of wavelet. The purpose of this paper is to improve and boost the features dissimilarities between the standard and contaminated lung parenchyma with the intention of making consistent visual evaluation. The main work flow carried out in this paper involves the following steps: In order to eliminate the pulmonary vessels of the lungs the structural filtering i.e., wavelet decomposition is used. For that the region can be classified into two different sub regions so that the difference of normality and abnormality can be detected. Next, feature localization is applied following image reconstruction step that aims to generate clean parenchyma intensity image on the basis of which quantification can be prepared. At the end, to enhance the intensity dissimilarities between the normality and abnormality, structure enhancement and classification is applied. The conclusion of this technique was that it involves a variety of limitations that makes the system not much effective and efficient. The work done in [12] is an enhancement technique of CT images. The technique basically makes use of full range of grey scale values in the process of histogram equalization. Many histogram equalization techniques have been proposed in the prospect of image enhancement. Compared to other methods, this system involves very less amount of calculations with lesser complexity. The results commenced from the method show that the algorithm is not only efficient in enhancing the image but also produces faster computations as compared to other histogram equalization techniques.

The similar work is done in [13]. The proposed solution is of enhancing CT images using a contrast based histogram equalization method. In this method the algorithm being proposed works in two steps. The first step works by taking two parameters i.e., the motion and sub block size. These parameters are used to calculate the local statistics. This step basically removes the artifacts present in the image together with reducing the calculation time. After this step the next action being taken is of histogram equalization that works on the altered local contrast extending operation. The system is tested on two sets of low dosage CT images. The outcomes showed that the process is efficient, reliable and flexible and has the ability to be utilized as a pre-processing device for low dosage CT images.

Image enhancement in brain imaging is also applied on 3D images. This type of work is done in [14] on 3D bagging CT images. These types of images usually suffer from the problem of background noise with the presence of low contrast factor in the image. In order to deal with this problem order static decomposition along with computer simulations is applied. The technique is basically a parametric thresholding method. First of all image de-noising is done which involves image slicing together with the order statistical decomposition process, as a result of which object image and noise image are produced. The object image is then passed to order statistical decomposition process to produce the image slice of enhanced image resulting in enhanced 3D volume CT image. The results showed that the process is useful for cluttered images having minute targets. It also has the ability of object segmentation and recognition. Another method [15] of CT images enhancement is proposed. Multilevel image enhancement is obtained by using the wavelet transformation in different ways. In each step noise is removed and enhancement is improved.

Another brain image enhancement approach is proposed in [16]. The author mainly focuses on the processing that has a consequence of contrast enhancement, noise reduction and contours determination for chosen ROI of diverse areas of diagnostic CT images.

Enhancement of brain images using the process of segmentation is carried out in [17]. The technique is basically an enhancement method of CT liver image. The method works by first segmenting the liver region and then applying the linear stretching process i.e., histogram equalization in order to adjust the contrast factor. Similar work can be analyzed in [18]; the method works by first preprocessing the image followed by a process of segmentation of the desired region and afterwards performing post processing to enhance the image. Another enhancement approach of CT images was presented in [19]. An additional method [20] of CT images enhancement was proposed. The proposed system first compiles clinically standard un-aphasic contrast injection protocols. Then another protocol was used to enhance the CT images generated by injection protocols. One more method [21] was introduced for the enhancement of CT images. The proposed algorithm was done by segmentation and enhancement. Segmentation was done by threshold method of grey-scale images and enhancement is done by adaptive histogram method. Proposed method is useful for enhancement and segmentation. Table 1 shows a comparison of brain image enhancement techniques in detail.

Electroencephalography (EEG) Enhancement Methods: The next enhancement technique is of EEG brain imaging proposed in [24]. In this paper an adaptive 'beam-former' spatial filter is utilized in order to improve the signals commencing deep basis inside the brain alleged of being epileptic form discharges (EDs). In order to determine the beam-former's spatial response constraints, a dipole

Table 1: CT brain images enhancement techniques comparison

Serial No#	Application	Advantage	Disadvantage	Results
1	Enhancement of CT images [11]	Enhances the CT images without affecting the intensity information	Proper selection of parameters is required to obtain the effective results. Normal subjects of images are not considered	-
2	Enhancement of CT head images [12]	The speed of processing is fast	Involves huge calculations	-
3	Enhancement of low dose CT images [13]	Reduces the calculation time, effective for removing tiny anatomies	Specifically designed for low dose CT images only	The outcomes showed that the system is an effective approach of noise removal with faster processing ability
4	3D CT baggage enhancement [14]	Controls the background details effect together with the darkness factor of CT baggage images	Enhancement of images with small targets applicable only	Showed better results as compared to other histogram equalization methods
5	Enhancement of CT images [16]	The method is effective for noise reduction, contrast enhancement and contours determination	Involves complex processing	Noise is removed 3 times of the present noise
6	Enhancement of CT liver image [17]	-	-	-
7	Liver CT Enhancement and Segmentation [18]	Can handle images that are invariant with respect to dimension, outline and intensity principles	Involves many processes	Accuracy of 96% was recorded
8	Content-based CT brain image retrieval [22]	Capable of cutting out background region, fitting ellipse to correct lean imaging angle and grey level normalization	Involves a lot of steps that slow down the system	Comparable enhancement results are recorded
9	Enhancement of MRI [23]	No damage of statistics or image veracity was noted in the definite brain parts of the managed MR Images	Specific to low field MRI images only	The results show that the process effectively manages the preservation of image information with optimal noise removal
10	CT enhancement [20]	Method is very efficient.	Complex normalization needed	Results show that the novel method is more efficient as compared to existing methods
11	CT enhancement and segmentation [21]	Automatic 2d enhancement	Computation is hard to understand	Proposed method is better and useful
12	CT enhancement [15]	Multistage algorithm	It has large computation time	Results are promising as compared to existing methods

source is used to record signals. In order to reduce the signals from source location, a least square algorithm is used. The algorithm as a result produces three outputs. Replications were carried out in view of utilization of identical forward structure to super impose reasonable EDs on usual EEG records. The results of this technique showed that the signals are enhanced by means of 120%. Method for EEG signals enhancement can be analyzed in [33]. The method is knowledge based system for incorporation of KBS methods with adaptive signal dispensation that unlocks a controlling path for commerce through objects, particularly in discerning among artifacts and compulsive waves in the persistent population and covers the method for an actual mechanized EEG examination through its whole potential savings.

Another approach for EEG signals enhancement was proposed in [34]. The method made use of a transform domain aimed at enrichment of periodic EEG signals in broadband clatter. In certain, outcomes are proposed in use of suggested impending EEG signals intended at tracing definite harmonics of concentration. The projected construction delivers better results paralleled to its conservative use.

EEG signals enhancement through the procedure of 3-D Adaptive Spatial Filtering is presented in [27]. The method uses a Non invasive process that makes use of an adaptive "beam-former". After that a spatial filter is examined aimed at the enrichment of signals commencing deep basis inside the brain doubted of comprising ED's. Next an onward three level spherical structure is utilized in order to narrate a dipolar foundation to verify signals for controlling the beam-former's spatial reaction limitations. The beam-former acclimates by the least-mean-squares (LMS) procedure in order to decrease signals commencing foundations distant to certain randomly defined positions in the brain. Another method for EEG/MEG enhancement can be analyzed in [28]. The method is basically enrichment of Level Bunching in the EEG/MEG Gamma Frequency Band Anticipates Evolutions. One more method was proposed [29] for enhancement of EEG images named as attention enhancement system. It increases the attention quality of children. A new approach [30] for enhancement of EEG/MEG images is presented. It is an analytical method by combining two methods i.e., magneto electroencephalogram for MEG images and

Table 2: EEG brain images enhancement techniques comparison

Serial No#	Application	Advantage	Disadvantage	Results
1	Enhancement of EEG data [12]	-	Depth and angular location of defect can be localized	Enhancement of EEG data was noticeability increased.
2	EEG signal enhancement [25]	Powerful avenue for dealing with artifacts	When used in real time, it may take unaccepted-ably long time to arrive at a decision of whether or not to remove an ocular artifact	The results proved that method is effective for EEG signal enhancement with the factor of bit slow processing
3	EEG signal enhancement [26]	Convergence speed and superior enhancement	-	The outcomes showed that FLC results were less effective as compared to this proposed method
4	EEG signal enhancement [27]	-	Comparably complex system	Results showed that method is an effective approach towards EEG signal enhancement
5	EEG signal enhancement [19]	Fast process and effective enhancement	-	Results showed that the proposed organization gives better results in comparison to the traditionally used full band technique called Fourier Linear Combiner (FLC)
6	EEG attention system [29]	It is very intelligent system	Difficult implementation	System is more efficient as compared to previous methods
7	MEG/EEG enhancement [30]	System is fast and has less complexity	Lengthy formulation	Results showed promising improvement
8	EEG\MEG enhancement [28]	Effective approach towards signal de-noising	Applicable to 2D images only	-
9	EEG enhancement [31]	Simple and fast	Normalization is required	Results showed that proposed method has good results as compared to others

electroencephalogram (EEG). In another technique [31] for enhancement of EEG images, 12 types of participants are selected and enhancement results are calculated. A comparison of EEG brain image enhancement techniques is shown in Table 2.

Magnetic Resonance Imaging (MRI) Enhancement Methods: The next method makes use of wavelet transform to enhance the MRI images. The work can be analyzed in [33]. The paper basically deals with nonlinear operators for the enhancement of MRI images. The algorithm being used in this technique is provided by means of spatial frequencies and basically decomposes the localized information of these frequencies. This process enhances the MRI images edges and at the same time checks the noise present in the image. The method showed results comprised of enhancement of obvious and barely seen features that make it easy to accurately diagnose the state of illness.

The method proposed in [34] deals with the noise removing images enhancement technique of MRI images by making use of global enhancement of images. Noise in this case is removed by applying the inverse histogram equalization to the mean images. This step also reconstructs the image. The next step taken in this case is the use of morphological operations to segment out the background in order to normalize the signal. After the background is segmented out, an average filter is projected on the image being segmented out in order to eliminate the factor of noise. Next step is to reconstruct the image that is done through the process of inverse histogram equalization. The results produced by the technique showed that the method is not only effective for eliminating the noise present in the image but also removes noise from the flow artifacts present in the MRI image.

Another enhancement technique in this prospect is discussed in [35]. The method proposed by them basically deals with the enrichment and noise destruction of MRIs with the help of white matter lesions. The technique proceeds by first preserving the edge information with the help of a fuzzy edge estimation process. The edges being achieved is the result of intensity information and edges themselves. The obtained measure is then used to remove the noise factor from the image with the help of thresholding process. After that integration procedure is functioned to reconstruct the noise free image. Image is reconstructed by using the edge map produced in this process that results in the smoothness of image. Component analysis is another approach to enhance the brain images. This type of work has been proposed in [32]. In this work component analysis of fMRIBOLD signals are proposed along with the removal of adverse constituents and then rebuilding of the statistics that can be utilized effectively as a method to assist distinct mission regarding voxel dissimilarity commencing non-task connected noise. Different applications of image enhancement in MRI can be analyzed in [36].

Another noise removal method in MRI images can be analyzed in [37]. The method works by creating residual energy factor to determine the required level of smoothing followed by a vector based PDE smoothing process. Another method of normalizing MRI using histogram equalization is proposed in [38].

De-noising an image using filtration process is carried out in [39]. The method first adds ricin noise in MRI images and then de-noising is performed by using order statistic filter that selects the parameters to remove noise from the image. Another approach in this context is noise reduction in MRI using Wave Atom Shrinkage [40]. This method also works on reduction of ricin noise from MRI images.

A technique for Image enhancement useful for Low-field MR Brain Images is proposed in [41]; the method works by first removing the unnecessary information from the image background followed by the process of segmenting the required region. After that Weighted Median (WM) is applied to remove the noise from the image.

Enhancement of MRI through the process of reconstruction is proposed in [42]. They proposed a new novel algorithm for sub-pixel super resolution images. Another related work is proposed in [22]; the method works by removing the background noise or irrelevant data from the image and then adjusting the ellipse to precise and accurate lean imaging level followed by a process of grey level normalization.

Noise reduction technique in low field MR images is proposed in [23]. The technique involves a series of steps which are background removal, artifacts elimination, normalization, segmentation and then histogram processing with the achievement that no important information was lost from the region of interest.

Another way of image enhancement is by the filtration process. The work done in this context is presented in [43]. The proposed method deals with the enhancement of DT-MRI data using the process of Locally Adaptive Filtering. The algorithm in this paper is

Table 3: MRI brain images enhancement techniques comparison

Sr No#	Application	Advantage	Disadvantage	Results
1	Enhancement of Human Cardiac DT-MRI Data [13]	Smoothing quality is good	Edges and images details are affected badly, sensitive to noise	Resulting obtained vectors are proved coherent
2	MRI enhacment [35]	-	-	-
3	Noise Reduction in BOLD-Based fMRI [31]	Effective for information recovery in FMRI	Process is complicated and unsupervised	The method is proved robust for using preprocessing process so as to take out the noise factor
4	Enhancement of MR diffusion tensor images [37]	Effective method for signals averaging	Computationally complex and a bit slow process	Minimizes the noise factor together with the factor of noise handling process
5	Enhancement and Unsupervised Segmentation of MRI Brain Image [9]	A fast and effective method containing both processes of enhancement and segmentation	The technique is merely with 2-D implementation	Effective for both enhancement and segmentation procedures
6	MRI resolution enhancement [45]	Handles many applications with 2D and 3D images	Computationally complex	Effectively handles the resolution method
7	MRI enhancement [8]	Method is stable, robust and needs very little manual interactions	-	Significant results of enhancement are achieved by the method
8	Unsupervised Segmentation and Enhancement of MRI Brain Image [46]	A fast and effective method containing both processes of enhancement and segmentation	The technique is merely with 2-D implementation	The results show that even in images with noise, the technique provides improved outcomes in segmentation and enhances images effectively
9	MRI enhancement [47]	Successfully removes typical signal intensity in homogeneities	Segmentation problem	Results demonstrate successful intensity normalization of MRI
10	MRI enhancement [48]	It is easy to implement and easy to understand	Greater computational time	The method has best results as compared to previous four methods
11	MRI normalization [48]	Algorithm is fast and useful for segmentation	Complex calculation	Results of proposed method are best
12	MRI enhancement [50]	Automatic reconstruction	Complex calculation	Results show that the proposed technique is fast and efficient than other techniques
13	MRI normalization [51]	Very fast approach	Complex calculation	Results are better than the existing approaches
14	MRI resolution enhancement [52]	Also for 3d images	Has large execution time	Proposed method has good results than existing methods
15	De-noising and enhancement of MRI [33]	Visual effect is more improved as well as enhances the edge and local details of the image	Computationally complex	Enhancement rate of 98.51 % is recorded
16	Enhancement of MR images [34]	Effective for both noise and artifacts removal	Effects/reduces the edge information of image	Effectively removes the noise factor
17	Enhancement of MRI [40]	The edge preserving property is clearly an advantage of the proposed method	Involves a lot of mathematics	The proposed method increases the SNR to a maximum of 57%
18	Noise reduction in MRI [39]	Advantage in de-noising complex MR images	Specific for ricin noise reduction only	The algorithm outperformed by better preserving tissue boundaries in the visual comparisons and also in the sharpness
19	Enhancement of MRI [38]	Applicable to all image segmentation, registration and analysis	Comparably a slow process	Effective for normalization and enhancement purposes
20	Enhancement of Low-field MR Brain Images [41]	Ability to retain the actual information of image and effectively handles the integrity of image	Specific for low field MR images only	The method managed to eliminate the unnecessary background and artifacts in the image
21	Enhancement of resolution in MRI [42]	Appropriate for handling the resolution factor	Computationally complex	Effectively handles the enhancement of resolution
22	Noise Suppression and Image Enhancement for FLAIR MRIs [44]	Image information and details are preserved	Specific for edge detection, not much effective for noise removal	Was found to provide on average 44.39% increase of noise attenuation in flat regions (smoothness) and a 34.14% increase in edge amplification (enhancement)

a combination of two methods i.e., non-stationary degree (NSD) notion and amoeba's algorithm. The method works by first taking into account the NSD process. In this process the NSDs at each pixel in the diffuse image are calculated. In the next step the calculated NSDs are introduced in amoeba's formulation algorithm. The places where the pixels are averaged are calculated that basically enhance the images. The results computed from this process show that the process is capable of preserving the edges and image detail along with the aspect of smoothing the homogeneous regions. Enhancement of FMR images using the process of reconstruction is proposed in [44]. The process works by utilizing the concepts of edge detection, intensity information and thresholding process. Related enhancement work using thresholding process is proposed in [45]; the method works by de-noising the images followed by a process of wavelet thresholding and applying the segmentation process at the end to adopt the region of interest.

Enhancement of resolution in MR images is proposed in [45]. The process makes use of an edge preserving operator to enhance the edges in the image and then applying edge reconstruction process to fully enhance the edge factor in the MR image. Another method for MRI enhancement is proposed in [8]. The method is basically an enhancement procedure for Small Brain Metastases in MRI. The method initially applies a clustering procedure in excess of each image pixel after which it carries out the process of histogram normalization with respect to parameters acquired by the clustering method. One further technique of MR images enhancement is proposed in [46]. The technique works by initially de-noising the image using the process of wavelet thresholding and after that minimum error thresholding is used to segment out the image. Consequently, the technique joins locally adaptive weighted median and acquires a local-wise segmentation. Normalization of MRI intensity can be analyzed in [47]. The method works by estimating a multiplicative improvement field to modify the concentration measurement of fan image or images set to go with that of a model. A new method [49] for enhancement of MRI images is an adaptive enhancement method in which an unsupervised segmentation by using Global-to-local is proposed. Method works on brain tissues. First image improvement is done by using wavelet thresholding. After this segmentation is done by using locally adaptive weighted median and fuzzy C-MEAN clustering. A novel algorithm [49] is proposed for enhancement of MRI images. In this algorithm intensity is first measured and then decreased by using Kullback-Leibler technique. So with proposed algorithm unwanted signals are removed, thus getting the best normalization and detection results. Another method [50] of MRI image enhancement is presented. Multi-bland algorithm is used for reconstruction of MRI images. After that affine motion model is applied for reconstruction process. One further technique of MRI image enhancement and normalization is introduced in [51]. As a clear image is required for good segmentation results, therefore, in the proposed method image is first normalized and then segmented. Skin-air-boundary method is proposed for this purpose. A novel method [42] is proposed for enhancement by using variation-based reconstruction. Edge enhancement method is also mugged with enhancement method to get good results. It also works on 3D images. A comparison of MRI brain image enhancement techniques is shown in Table 3.

Positron Emission Tomography (PET) Enhancement Techniques: The next enhancement technique deals with the PET images. This technique which is proposed in [53] deals with improving the PET signal with the help of novel non-linear neuro anatomical registering procedure. The method basically achieves a hierarchically scrambled examination designed for a dislocation field, taking full advantage of one of

Table 4: PET brain images enhancement techniques comparison

Serial No#	Application	Advantage	Disadvantage	Results
1	Enhancement of multivariate signal of PET [53]	Has ability to compare different methods in this regard	It does not much improve the registration factor of image	-
2	De-noising the PET images [54]	Increase in sensitivity of emission images with minimal resolution loss	Computationally complex	The outcomes proved that the technique is effective for enhancement with practical implementation and fast processing
3	PET\CT enhancement [55]	Functional image improvement is especially effective	-	Results demonstrated the method as an effective approach of PET and CT enhancement

Table 5: Medical brain images enhancement techniques comparison

Serial no#	Application	Advantage	Disadvantage	Results
1	De-noising or enhancement of medical images [16]	Effective for noise reduction and segmentation and handles both 2D and 3D images	Involves lot of calculations	Results demonstrated that method is robust for segmentation and enhancement processes
2	Enhancement of medical images [17]	The speed of histogram equalization is considerably enhanced	Not practical for 3D medical image enhancement because of its complicated calculation	The proposed method shows the enhancement performance as well as the enhancement speed is considerably better

numerous voxel resembled actions commencing from the 2-D histogram of corresponding intensities of image. The method presented was evaluated on water PET statistics area and confirmed to generate a recording better and advanced to a conventional method of 12-parameter affine registration. The main feature measured and observed in this case is the enhancement of cortex edges. Enhancement using the de-noising process is carried out in [54]. The method works on the solution possessions of wavelet transform for the enhancement of PET images.

An approach to PET enhancement is proposed in [55]. The method being adopted is functional to anatomical image adaptation which is centered on correlated nonlinear diffusion. Morphological correlation is used in order to find the functional image structures analogous to anatomical images. A comparison of pet brain image enhancement techniques is shown in following Table 4.

Medical Image Enhancement Methods: Here we will analyze some of the methods proposed for overall medical image enhancement:

Enhancement method by noise reduction is proposed in [56]. The technique makes use of a process called non-linear and non-iterative noise reduction method. Image enhancement using histogram equalization is also performed in [57].

Another comparison of medical brain image enhancement techniques is shown in Table 5.

CONCLUSION

So far we have analyzed and discussed different methods and approaches developed and proposed in the prospect of brain image enhancement. In view of the above analysis of these techniques, it has been concluded that there are six main types of brain imaging. Enhancement in the prospect of NIRS is not carried out by any method. Most of the work in enhancement field is done in view of CR and MR images. There still exists a need to propose and present different new and effective methods for brain image enhancement. From the above discussed methods and techniques, we cannot basically determine which method is best or optimal because unluckily there is no universal presumption for determining what optimal image enhancement is when it approaches to human observation. Conversely, while image enhancement methods are utilized as pre-processing apparatus for further image dealing methods, quantitative actions can decide which methods are mainly suitable and optimal? But we can say that the image enhancement in medical field is basically carried out in order to make things clearer and accurate that helps to effectively and precisely determine and deal with the problems and facts in the brain images. Here we can analyze different ways by which the approaches discussed above manipulate images in view of image enhancement. This analysis is shown in figure 7.

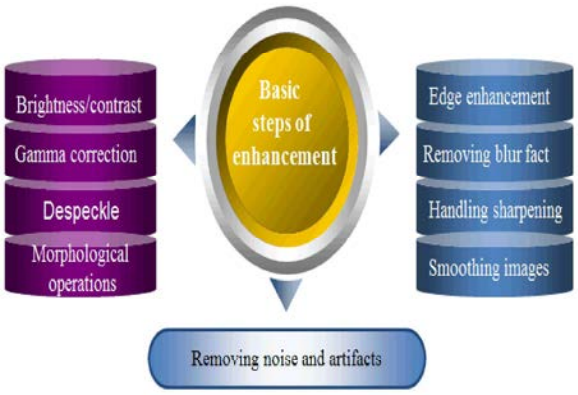

Fig. 7: Basic steps of image enhancement

The paper is a short description and analysis of the techniques and methods proposed and implemented for processing brain imaging types in the prospect of enhancement. There are six main types of brain imaging, each type is analyzed and discussed by means of different enhancement methods that are applicable to them. A comparison of different brain image enhancement

approaches with respect to their applications, advantages, limitations and results is also discussed and presented. It is observed from the analysis that huge work has been done in this regard but still there exists more space for further work.

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