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Brain Image Reconstruction: A Short Survey

Mussarat Yasmin, Muhammad Sharif, Saleha Masood,
Mudassar Raza and Sajjad Mohsin

Department of Computer Sciences,
COMSATS Institute of Information Technology Wah Cantt, 47040, Pakistan

Abstract: Brain image reconstruction, assessment, formation and investigation consent quantifiable examination and conception of brain images of a variety of modalities such as MEG, EEG, PET, MRI, CT or microscopy, to name a few. The basic purpose of reconstruction 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 image reconstruction provides a way to investigate and determine brain related diseases in an efficient and effective manner. Reconstruction of brain images is a vast field in dealing with these images. This study is conducted with the basic purpose of evaluating and discussing 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 reconstruction.

Key words: Brain · Medical · Image Processing · Reviews · Disease Analysis

INTRODUCTION

The process of image reconstruction can be defined as: A method of adding two-dimensional images into a computer followed by enhancing or investigating the image by putting it into a shape that is further constructive and helpful to the human spectator. Reconstruction process from the medical prospect is visualized in the following figure:

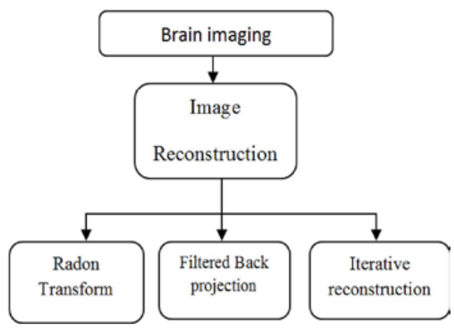

Fig. 1: Image reconstruction branches

Now what these processes are can be analyzed from the figure given below:

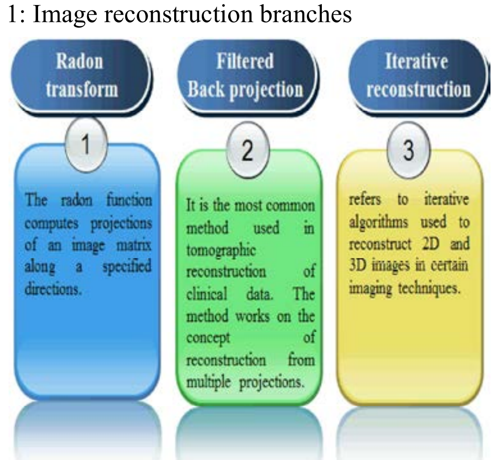

Fig. 2: Image reconstruction processes

Reconstruction process [1] is very useful and applicable in handling the MEG. EEG, MRI, CT and PET brain images. Huge work has been done in this field. In this paper, we will analyze different techniques proposed in this prospect.

Techniques Discussion and Evaluation

MEG Image Reconstruction: MEG basically examines the working carried out in the brain tremendously- 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. Now we will analyze different reconstruction methods proposed in this context.

Corresponding Author: Muhammad Sharif, Department of Computer Sciences, COMSATS Institute of Information Technology Wah Cantt., 47040, Pakistan. Tel: +92-300-5188998.

Table 1: MEG brain images reconstruction methods comparison

Serial No#	Application	Advantage	Disadvantage	Result
1	Reconstruction of MEG data [2]	A new angle has been offered in medical imaging studies to explore theories of pattern recognition	Too expensive calculations to practice and with various sorts of noise, sensitivity of MEG measurement is high	Parameter estimation, pattern recognition and signal modeling cannot be applied for the solution of problem like this or similar
2	MEG reconstruction [3]	Effectively handles both noise and resolution factors	Contains two separate systems that can slow down the system	Results have a bridged arbitrary noise, concentrated stopping dipole content and improved tenacity of insulated dipoles than an unstandardized image renovation
3	Reconstruction of MEG and EEG [6]	Works well even in the presence of anisotropic conductivity	Does not improve reverse reconstruction	The problem of computational complexity is dramatically reduced
4	The technique is appropriate to consequences of cradle reconstruction from suggested MEG/EEG dimensions [4]	The usage of the projected system is not restricted to the spatial filter preparation and it can be utilized by means of any kind of basic reconstructionapproaches	Computationally complex	Reconstructs any type of source

The work done in [2] is a method presented in this perspective. The method being projected is comprised of a reconstruction method of MEG using a variation EM algorithm. The method works by partitioning a particular part of the cortex by assuring that the portioned brain part really contains the stimulated electronic activities. In order to reflect the information of the source location a special source model is used that works by making multiple unknown parameters. Next EM algorithm is applied in order to solve the problem of parameters optimization. The results showed that the system contains very simple construction with fewer and simple calculations. Another MEG reconstruction technique is by use of markov random fields; this type of work is proposed in [3]. The method makes use of a potential function and a sampling process. MEG reconstruction using thresholding concept is performed in [4]. It is a statistical method proposed to mine objective source actions from MEG/EEG source reconstruction outcomes. The thresholding process is performed using a spatial filter reconstruction process. A method for reconstruction of both MEG and EEG data is presented in [5]. The technique is centered on an explanation of volumes through spherical harmonics and a database of scrupulous façades. Consuming the method one can reconstruct and segment out the region of interest with less effort and less time. Similar work for EEG and MEG is presented in [6]. The process is centered on volume transmission possessions in the reconstruction of EEG/MEG on the basis of Primary Left Anterior Negativity. Table 1 summarizes the MEG brain images reconstruction methods comparison.

PET: PET was the initial examination technique to provide functional knowledge related to 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.

PET Image Reconstruction: Now we will analyze different reconstruction methods presented in this prospect.

Reconstruction of PET images is carried out in [2]. The method is a reconstruction approach of PET images using a Wavelet Domain Bayesian Method. The paper contains a technique of PET image reconstruction that is basically defined and carried out in a wavelet domain. The working flow carries firstly a Wavelet based measurement model followed by a process of decomposition strategy. Image in this case is mainly reconstructed on the basis of extracted coefficients. The results showed that it is a good technique for extracting both local and global features. Reconstruction of 3D images is also done. We can analyze [8] in this regard. The technique works on reconstruction of 3D PET images using Inverse Fourier Rebinning method. The reconstruction is carried out by the use of Fourier rebinning process that makes a back projection pair for reconstruction process of PET 3D. In this case the combination of Fourier rebinning and iterative reconstruction process makes the factored image matrix using a shift variant sonogram blur kernels. In this case a forward projector is used that firstly maps the 3D PET into 2D sonograms and then inverse rebinining is processed to map the 2D singrams back to 3D. Next a back projector is used to transpose the projector. The results of the technique showed that the resolution of edges is slightly affected. Another method in the processing of PET data is proposed in [9]; the paper reconstructs the kinetic parameter images from the PET data. The method makes use of Bayesian frame work in order to reconstruct the images and then afterwards uses procedure of parametric iterative coordinate descent (PICD) in knowledge for resolving the optimization problem. The PICD algorithm in this case is applied by means of spatial directive in the area of physiologically significantfactors. The results showed that the system reduces the mean squared error and involves less computational factor. Another approach of reconstruction of PET data using thresholding process is performed in [10]. The model works y using filtered back projection way for the reconstruction process. Work on 3D brain images is also carried out; a work of reconstruction on PET images using the process of back projection is proposed in [11]. 3D PET data reconstruction using the process of voxel assemblies together with the concept of independent adaptive projection of data is presented in [12]. The method is based on the utilization of intrinsic symmetries followed by the process of adaptive projection. Significant matrix compression ratio is achieved by this process with the feature of minimizing the reconstruction time. Reconstruction approach for PET data using Monte-Carlo System is proposed in [13]. In this method superiority of the reconstructed image was judged by means of dissimilarity revival against background noise. Momentous enhancement was established with consideration to the typical ray-tracing ML-EM. Using sparse spectral representation for direct reconstruction of PET data is proposed in [14]. Laplacian prior is used in this case to carry out the process. Another projection based reconstruction of PET 3D data is proposed in [15]. The technique is centered on the idea of nontraditional, tensor and harmonizing customs of illustrationof 3-D image by means of 3-D discrete Fourier transform. A new technique within a clinically relevant time frame for PET image reconstruction is presented in [16]. The method works by using the concept of iterative reconstruction procedure of ordered subsets expectation maximization (OSEM) together with parallelization for the sensitivity handling factor and sensitivity normalization matrix calculation. The results showed that it is possible to achieve 3D image reconstruction within a clinical relevant time frame. Pet reconstruction by back projection and ultra-symmetry algorithm can be analyzed in [17]. PET image reconstruction through Multiphase Level Set Method is presented in [18]. An original MAP technique to reconstruct equal PET image by means of piercing limits through joining lacking functional edge facts in a Bayesian background is offered. The consequences exhibited that image quality is improved through the method. Evaluation of noise in the PET image reconstruction is presented in [19]. The method is based on point spread function (PSF). Different noise metrics are calculated to carry out the task. The results are properly evaluated for each sort of noise. PET image reconstruction by means of Nonlocal-Means Approaches to Anatomy is presented in [20]. The method makes use of non local-means algorithm together with maximum a posteriori (MAP) and the minimum cross entropy (MXE) reconstruction methods. The results show that the method outcomes really effective and efficient results in regard of image reconstruction and percentage error and regional bias is improved and handled in an effective way. PET image reconstruction by means of Phantom Study of Regularized Image can be analyzed in [21]. Areas of concentration were located on the images and the picture superiority was calculated as difference resurgence, background inconsistency and signal-to-noise ratio crossways the ROIs. Through this method even very small regions of the image are enhanced effectively. Results showed that the method is effective for reconstruction and image enhancement as well. Reconstruction of PET data from spatiotemporal reconstruction is proposed in [22]. The method is basically a reconstruction way to trace out the time estimate of tracer density by utilizing the PET information together with the theory of in homogeneous Poisson Process. PET brain images reconstruction methods comparison is given in Table 2.

MRI: It occupies incredibly quick examination of the 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 [23] 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.

MRI Image Reconstruction: Now we will analyze different methods presented in this prospect. Image reconstruction of MRI can be analyzed in [24]. The method is MR reconstruction using least square quantization table. The method in this case makes use of Fourier transforms; these transforms work on uniformly sampled

Table 2: PET brain images reconstruction methods comparison

Serial No#	Application	Advantage	Disadvantage	Result
1	PET Image Reconstruction [7]	This method showed good performance in the extraction of an image local as well as global features	Computationally complex	Effectively restores the PET images
2	3D PET data reconstruction [8]	Applicable to both 2D and 3D data	Image resolution of edges is affected	The novel projector outcomes a minor damage in resolution in solitary near the field-of-view control after associated with an entirely three-dimensional symmetrical projector requiring an instruction of fewer calculation
3	Renovation of Kinetic Parameter Images [9]	Decreases the mean squared inaccuracy in model limitation approximations and does not necessitate abundant calculations	A complex system	Kinetic Parameter Images are effectively reconstructed by using less computations
4	3D PET reconstruction [11]	Fast and bit reliable	Procedure can only virtually be functioned to images up to a concentrated extent of 64x64~64 voxels	Deals small enhancements in diverged noise enactment as associated to BPF and meaningfully recovers junction possessions when matched to ISRA
5	Reconstruction of List-Mode PET Data [22]	Handles both 2D and 3D data	Lack of temporal stationary	Sprinkle is comparative to the chronological distribution of the trues. A measurable assessment was executed by means of replicated figures and the technique consuming 11C-raclopride is also established in a human study
6	PET reconstruction [10]	Image quality of PET reconstructions were greatly improved	Doesn't contain much cons	Multi scale normalized FBP produced image statistics through greater difference and aspect
7	3D PET reconstruction [12]	More precise image space sampling delivers meaningfully enhanced images in expressions of resolution and noise	Higher computational effort	The process effectively reconstructs the data with preserving image quality and details
8	Reconstruction of PET data [13]	Handles both noise and contrast factors	Blurring effect	Important enhancements were achieved by means of standard Ray-tracing ML-EM technique
9	Reconstruction of PET images [14]	Preserves the information	Computationally complex	Technique accomplishes improved bias-variance adjustment than a conservative secondary process for approximating parametric images from active PET data
10	Reconstruction of PET data [15]	Preserves image details and quality and can handle both 2D and 3D images	Limited to image size of 256x256 and in 3D 32x32x32	Significant improvements are achieved by using the tensor representation in the reconstructed image
11	PET image reconstruction [16]	Can be implemented in real time frame	Practically expensive	Results showed that within a clinical relevant time frame 3D image reconstruction is achievable
12	PET image reconstruction [17]	-	Large and complex system	-
13	PET image reconstruction [18]	Image quality is improved	Mathematically complex	The results showed that the method improves the image quality
14	PET image reconstruction [19]	Handles all sorts of noise	-	Results showed that the method is effective to handle different kinds of noise
15	PET image reconstruction [20]	Percentage error together with regional bias are improved and handled in an effective way	-	The method outcomes really effective and efficient results in regard of image reconstruction
16	PET image reconstruction [21]	Even the very small regions of the image are enhanced effectively	SNR values become fixed at the end which is not good	Results achieved by the method are effective and showed that the method is efficient for reconstruction and image enhancement as well

data. The method starts by classifying the image pixels into numerous assemblies. First, it categorizes each pixel of image into the Lloyd-Max quantization arrangement. LSQT is then used to store the data and information of each pixel group. Next the contribution of each group is calculated. At the end mapping is done using nearest grouping method with the representative values of pixel groups. The results showed that the method requires far less memory consumption; reconstruction in this case is less but involves fewer complex calculations. Use of neural network for the process of MRI reconstruction is presented in [25]. Low frequency MR Information is used to train the neural networks. Effective results are obtained by the method because multifaceted appreciated system makes practice of the consistent substantial in the complicated statistics in its place of treating the data as distinct realand imaginary portions. MRI reconstruction using another approach called SVD is presented in [26]; the method collects the raw data and then dis-cretizes in a k-space. The method is combined with the process of Root mean square. Results indicate that it is more appropriate for the reconstruction of MRI. A filter based approach for MRI reconstruction is proposed in [27]. This paper formulates the image reconstruction problem as a digital filter bank problem. But the approach still fails to address many problems and issues. The method will be effective for reconstruction process if large number of coils is used in order to gain high speed. MRI reconstruction using the concept of weighted correlation is presented in [28]. Another MRI reconstruction approach is proposed in [29]. The method makes use of a concept called Visual Divergence Predictor that is basically used to analyze the image quality. The outcomes of the method showed that this beginning study points out that these actions are hopeful as functional pointer of supposed image quality. Parallel MRI reconstruction can be analyzed in [30]. Another method of MRI reconstruction is proposed in [31]. By means of mathematical simulations, the method illustrated that the novel interpolators are able to give iterative non-Cartesian inversion algorithms by means of significantly abridged memory requirements. In order to remove the moving artifacts from the MRI reconstruction process, a method proposed in [32] can be analyzed. The technique initially takes on Homomorphic filters and B-spline smoothing in order to acquire a group of consistent intensity phased array coil images and then precisely predictable corrupt models are centered on mutual data among the coil images. Lastly, weights are relocated by means of estimative information in the following joint procedure. In this approach the pressure of crooked models is attenuated with the intention that the motion artifacts in reconstructed images might be successfully reduced. Another method for MRI reconstruction is presented in [33]. The method makes use of multiple non interacting receiver coils. The method is not implemented practically but is analyzed with all its pros and cons. The method greatly reduces the number of phases that are required in encoding acquisition in imaging sequence. Assessment of noise objects in the MRI renovation process is presented in [34]. The method makes use of perceptual difference model to convey out the job. The method works through computing the graphical iteration among the examination image and a typical image. The results showed that the lesser amount of inserts by superior amount of sampling is required when dealing with the noise factor. Another MRI reconstruction method is presented in [35]. The method works mainly by focusing the phase components; distinct regularization of scale and stage mechanisms is offered. The consequences exhibited that the method effectively handles the spatial resolution of the magnitude and phase components are strongly regularized. MRI reconstruction using the concept of homomorphic signal processing is presented in [36]. The method works by utilizing the spectral of the valuable coil signal, coil compassion and nonlinear transform that handles the image contrast. The results showed that the method not only removes the noise but also manages the contrast and resolution of the image. A method of MRI reconstruction by means of relative sensitive profiles can be analyzed in [37]. Another reconstruction approach for MRI is presented in [38]. The method is based on the concet of Minimization of a Complex Norm. The outcome of the method illustrates that the performance of the projected method presents a convinced enhancement in excess of other conventional methods. MRI based Bayesian reconstruction method can be analyzed in [39]. The method works for improving the quality of image using the concepts of canny edge detector, a smoothing filter and modified markov random field. The maximum a posteriori (MAP) algorithm is used for the reconstruction method. The results showed that the reconstruction method produces image with less noise and improves the image resolution. An overview of MRI brain images reconstruction methods comparison is given in Table 3.

Table 3: MRI brain images reconstruction methods comparison

Serial No#	Application	Advantage	Disadvantage	Result
1	MRI reconstruction [24]	Effortlessly flexible to a multiprocessor scheme and needs far fewer recollection to store image	Specific for high quality large size images	The LSQT technique delivers renovations that are extra precise when a suitable parameter is selected
2	MRI reconstruction [25]	Image quality is preserved	Utilizes complex data and computationally complex system	Larger enactment of the complex-valued system is achieved at the consequence of the system
3	MRI reconstruction [27]	Successfully works even when big number of hastening issues are involved	Sensitive to noise	The method significantly improves the reconstruction in parallel MRI
4	MRI reconstruction [26]	More suitable for MRI reconstruction	A bit slow system	Method achieves much better results and accordingly it will be more suitable for MRI image renovation
5	MR images reconstruction [28]	-	-	-
6	MRI reconstruction [29]	Quantitative measures of image quality are preserved	-	The results showed that as useful indicators of perceived image quality, these measures are promising
7	Reconstruction of MR images [30]	Attains equilibrium among noise strengthening and stage objects	Computationally slow	Results showed that the method produces less noisy image
8	MR images reconstruction [31]	Works on system with limited memory requirement	Performance factor remains the same	The consequences exhibited that there is no alteration in enactment of this method and existing approaches but needs lesser memory
9	Noise removal in MRI reconstruction [32]	Image resolution is significantly improved	Computationally complex	Method reduces the motion artifacts caused by the corrupt data in the reconstructed images
10	MRI reconstruction [33]	Preserves image resolution and view	The method is not practically implemented yet	The method results in reduction of number of phases that are required in encoding acquisition in imaging sequence
11	MRI reconstruction [34]	Removes the artifacts from the reconstruction process	-	The method is applicable to a great extent in regard of noise reduction from the MRI reconstruction process
12	PET image reconstruction [39]	Improves image resolution and produces images containing less noise	-	The results showed that the reconstruction method produces image with less noise and improves the image resolution
13	MRI reconstruction [35]	The method results in better reconstruction than other existing methods	Computationally complex	The results showed that method is effective for MRI reconstruction and provides better outcomes
14	MRI reconstruction [36]	Simple and effective for handling noise, contrast and resolution factors of image	-	The results showed that the method not only removes the noise but also manages the contrast and resolution of the image
15	MRI reconstruction [37]	-	Fewer artifacts are obtained when image is reconstructed	The results showed that method results in artifacts within the reconstructed image
16	MRI reconstruction [39]	Improves the image quality	Computationally complex	The outcome of the method illustrates that the performance of the projected method presents a convinced enhancement in excess of other conventional methods

EEG: Electroencephalography (EEG) is the measurement of electrical actions and movements of brain 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 occurrence.

Table 4: EEG brain images reconstruction methods comparison

Serial No#	Application	Advantage	Disadvantage	Result
1	EEG Brain Map reconstruction [40]	Enables real time reconstruction of the images	Involves complex computations	The results show a big improvement in analysis of the reconstructed image
2	EEG and MEG reconstruction [5]	Involves less complexity and time	Image quality is affected	High rate of segmentation and reconstruction is achieved

Table 5: EEG brain images reconstruction methods comparison

Serial No#	Application	Advantage	Disadvantage	Result
1	Reconstruction for cerebral blood flow Quantification [42]	Fast process and involves less complexity	Not much reliable process	In estimated arterial peak enhancement relative error gets decreased from 14.6% to 10.5%
2	Reconstruction of CT [41]	Fast and accurate system	Deals with reconstruction of realistic-size images only	Zero loss in image quality
3	CT reconstruction [43]	Reduces overhead to very moderate levels	A bit complex system	Results showed that in GPU-accelerated iterative reconstruction benchmark-based parameter selection can be used for making iterative reconstruction a perfect choice for CT regarding a few-view scenarios and noise
4	CT reconstruction [44]	Effective for 3D data	Computationally complex and expensive	The proposed method accelerates the reconstructions by roughly a factor of hree on average for typical 3-D multi slice geometries
5	Applicable in medical image compression [52]	Decreases the space for data storage	Comprises few errors in the method	Effectively reconstructs the image using smaller space
6	CT image reconstruction [45]	-	Mathematically complex, resolution factor is not handled properly	The results showed that method produces satisfactory results but not much effective
7	CT image reconstruction [46]	-	Expensive and complex method	Effective for CT image reconstruction
8	CT image reconstruction [47]	Image quality is preserved	-	Effective and simple method for CT images reconstruction
9	CT image reconstruction [48]	-	Large and computationally complex system	The method can be used for CT image reconstruction
10	CT image reconstruction [49]	Practically useful for CT image reconstruction	-	The results showed that half precision data and raw data can be utilized in image reconstruction
11	CT image reconstruction [50]	-	Complex and expensive system	Satisfactory results are obtained in regard of CT image reconstruction
12	CT image reconstruction [51]	Reconstructs the series of 2D image and displays the result as 3D	A variety of problems exist in the method that need to be improved	The results obtained by the method are satisfactory

EEG Image Reconstruction: Reconstruction process on EEG brain type can also be analyzed. This type of work is proposed in [40]. The author works by using the concept of blind signal separation together with the process of spectrum estimation. Table 4 gives a comparison of EEG brain images reconstruction methods.

CT: CT is basically examining a picture 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.

CT Image Reconstruction: In [41] reconstruction of CT images is proposed based on a concept named metal artifact reduction. The approach makes use of a process called polychromatic sonogram formulation that takes into account the beam hindering effect. Significant results are obtained with no loss in image quality. Advancement in processing brain images can be analyzed in [42]. The method is not available right now but will help out to reconstruct 4D brain MRI and CT images. Hardware based reconstruction of CT can be analyzed in [43]. Particularities related through the GPU hastening of these are focused through this method. In order to control the optimal locations of numerous parameters in iterative method,they present the knowledge of using comprehensive standard trials. Another CT reconstruction approach based on the concept of Spatially Non homogeneous ICD Optimization is presented in [44]. The process is capable of handling both 2D and 3D data together with an acceptable rate of reconstruction. Another CT image reconstruction method for CT images is presented in [45]. The method makes use of floating point graphics for this purpose. The results showed that method outcomes satisfactory results but not much effective. Another CT image reconstruction method by means of Cell Broadband Engine is presented in [46]. The method is complex and expensive in real time frame. CT image reconstruction through hexagonal grids is presented in [47]. The method can be utilized with existing reconstruction methods. The method is effective and outcomes efficient results in regard of image reconstruction of CT images. CT image reconstruction using Larrabee can be analyzed in [48]. The method is complex and large and practically difficult to implement. Similar method is presented in [49]. CT image reconstruction using 512-point FFT/IFFT reconstruction algorithm is presented in [50]. The method is complex and expensive; satisfactory results are obtained in regard of CT image reconstruction. Three dimensional CT image reconstructions can be analyzed in [51]. A technique presented in [52] can be analyzed for compression as well as for reconstruction process. The method makes use of a Fourier algorithm in order to lessen the amount of information or details being stored in the original image. The method produces a matrix that is further analyzed in order to extract the maximum frequency components which are further used for compression and reconstruction process. A comparison of EEG brain images reconstruction methods is shown in Table 5.

DISCUSSION

In the above section we have discussed and evaluated different techniques proposed in the prospect of brain image reconstruction. A comparison table is also derived in order to analyze the application, advantages, limitations and results of different approaches in this regard. In short, we can say that image reconstruction is a process that comprehends the complete image creation procedure and delivers basis for the succeeding phases of image dispensation. The objective is to repossess image information that hasbeen vanished in the procedure of image development. Radom transform, iterative reconstruction and back projection are three main processes in regard of image reconstruction.There are a number of methods which are used with these processes to carry out the reconstruction.

CONCLUSION

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 reconstruction. There are six main types of brain imaging; each type is analyzed and discussed by means of different methods that are applicable to them. The brain images are discussed from the prospect of reconstruction and different ways that are proposed and implemented in this regard. There are basically two main types of brain image compression. Each type with its all reconstruction methods is discussed and presented. A comparison of different 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 space for further work.

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