AnAlternate Approach in Resolution Enhancement for MRBrain Image

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ABSTRACT—*Inrecentyears,theoccurrenceofbraintumorhasbeenontherise.Alotof methodshavebeenproposedtoobtainmedicalimages(CTscan,differenttypesofX-rays,MR imagesandotherradiologicaltechniques)forfurtheranalysis.Majorproblemintheimages obtainedthroughtheabovesaidmethodsisthepresenceofblur,noise,artifacts,anddistortion. Evenasmallamountofnoisemayleadtofalsediagnosis.Hencethereisaprerequisiteforthe reductionsofnoisesforcorrectdiagnosis.ToreducethenoisepresentinMRimage,inthispaper differentfiltrationtechniquesareusedandtheirperformancesarecomparedbyevaluatingMSE andPSNR.Oncewhentheimageisfiltereditsqualitygetsdegradedandhencetoenhancethe qualityofanimage,anovelresolutionenhancementtechniquewhichgeneratesahighresolution imageisproposed.Inthiswork,DWTisappliedtodecomposealowresolutionimageinto differentsubbands.SimilarlySWTisalsoappliedtodecomposeanimageintodifferentsubbands. Then the three highfrequency sub band images ofDWT isinterpolated using bi-cubicinterpolation. Thehighfrequencysub-bandsobtainedbySWToftheinputimagearesummeduptothe interpolatedhighfrequencysubbandsinordertocorrecttheestimatedcoefficients.Inparallel,the inputimageisalsointerpolatedseparately.Finally,correctedinterpolatedhighfrequencysub bandsandinterpolatedinputimagearecombinedbyusingIDWTtoachieveahighresolutionMR image.Theperformanceofthistransformtechniqueisanalysedquantitativelywiththe conventionalDWTandSWTmethods.ThePSNRfortheproposedmethodisfoundtobe10dBto 20dBmorethantheconventionalmethods.Thustheresultsobtainedprovedthattheproposed technique givesa better qualityimage.*

Keywords—MagneticResonance(MR),DiscreteWaveletTransform(DWT),Stationary WaveletTransform (SWT), Peak Signalto Noise Ratio(PSNR), Mean Square Error (MSE).

1, INTRODUCTION

Braintumorisanabnormalgrowthoftissuesin thebrainandismainlycausedbyradiation totheheat,geneticrisk,HIVinfection,cigarettesmokingandalsoduetoenvironmental toxins.Noaccuratedetectionoftumorregionispossibleduetothepresenceofnoisein MRimage.Evensmallamountofnoisecanchangetheclassification.Graymatterismade upofneuronalcellbodies.TheGraymatterincludesregionsofthebraininvolvedin musclecontrol,sensoryperceptionsuchasseeingandhearing,memory,emotions,and speech.Whitematterisoneofthetwocomponentsofthecentralnervoussystemand consistsmostlyofglialcellsandmyelinatedaxonsthattransmitsignalsfromoneregionof thecerebrumtoanotherandbetweenthecerebrumandlowerbraincenters.Noisyimage cancausemisclassificationsofGrayMatter(GM)asWhiteMatter(WM).Sothenoiseis preprocessedusingdenoisingtechnique.Resolutionenhancementisusedtopreservethe edgesandcontourinformation.Themajorapplicationofthesetechniquesisdetectionof tumor cells in human body[1, 2].

Tosignificantlyacceleratethedenoisingalgorithm,thefiltersareintroducedto eliminateunrelatedneighborhoodsfromtheweightedaveragetoreducenoiseateach imagepixel.Thesefiltersarebasedonaveragegrayvaluesaswellasgradients,pre-classifyingneighborhoodsandtherebyreducingthequadraticcomplexitytoalinearone anddiminishingtheinfluenceofless-relatedareasinthedenoisingofagivenpixel.Partof theongoingeffortsincludestheinvestigationofimagecharacteristicsthatprovidegood contextclassificationsforimagedenoising[3].Althoughtheinversefilterworkswell whennonoiseispresent,theWienerfilterperformsmuchbetterandismoreversatile which is discussed in [4].

Resolutionhasbeenfrequentlyreferredasanotherimportantaspectofanlmage. Oneofthecommonlyusedtechniquesforimageresolutionenhancementislnterpolation. Interpolationhasbeenwidelyusedinmanyimageprocessingapplicationssuchasfacial reconstruction[5],multipledescriptioncoding[6],andsuperresolution[7,8].Inthis correspondence[9],theauthorsproposeanimageresolutionenhancementtechniquebased oninterpolationofthehigh frequencysub bandimages obtainedbydiscretewavelet transform(DWT)andtheinputimage.Theedgesareenhancedbyintroducingan intermediatestagebyusingstationarywavelettransform(SWT).Thequantitativeand visualresultsareshowingthesuperiorityoftheproposedtechniqueovertheconventional and state-of-art imageresolution enhancement technique.

2, PROPOSEDWORK

Theproposedworkcanbedividedintotwostages:(i)Denoising(ii)ImageEnhancement. InMRimages,thepresenceofnoiseisunavoidable,henceinthefirststage,theimageis filteredusingthreedifferentfiltersandtheirperformancesarecompared.Sincethe resolutionofanimageisdegradedbecauseofthefiltration,inthesecondstagethefiltered imageisenhancedusingdifferentwavelettransformtechniquesandtheirresultsare comparedbycalculatingMSE andPSNR.

2.1 DenoisingMechanism:

Toanalysethemedicalimage,initiallythenoisemustberemovedfromtheMRimagefor retainingtheoriginalinformation.Noiseinmedicalimagingismainlycausedbyvariation inthedetectorsensitivity,reducedobjectvisibility(lowcontrast),chemicalor photographiclimitations,andrandomfluctuationinradiationsignal.Inthiswork,three filters:Mean,MedianandWeinerareemployed.ItisfoundthatthePSNRvalueofthe image filtered using Weineris better compared tothe other two.

2.1.1 Mean filter

Meanfilteroraveragingfilterisasimplelinearfilterandaneasymethodforsmoothingof images.Averagefilterisoftenusedtoreducenoiseandtheamountofintensityvariation fromonepixeltoanother.Here,anaverageofthenxnpixelelementsiscalculatedand theneachpixelinanimageisreplacedbytheaverageofpixelsinasquarewindow surrounding this pixel.

$$h(i,j) = \frac{1}{M}\sum_{(k,l)\in N} f(k,l) \quad (1)$$

M is the total number ofpixels in the neighborhood N and k, l=1, 2….
Themajorproblemwithaveragingoffilteristhatitcanremovenoisemoreeffectivelyin largewindows, but blur thedetails in an image.

2.1.2 Median filter

Medianfilteringisanonlinearoperationoftenusedinimageprocessingtoreducenoise.A medianfilterismoreeffectivethanconvolutionwhenthegoalistosimultaneouslyreduce noiseandpreserveedges.Itissimilartoameanfilterbutinsteadofsimplyreplacingthe pixelvaluewiththemeanofneighboringpixelvalues,itreplacesitwiththemedianof thosevalues.Themedianiscalculatedbysortingallthepixelvaluesfromthesurrounding neighborhoodintonumericalorderandthenreplacingthepixelbeingconsideredwiththe middlepixelvalue.Advantageofmedianfilteris:thereisnoreductionincontrastacross steps,sinceoutputvaluesavailableconsistonlyofthosepresentintheneighborhood(no averages).Thedisadvantageofmedianfilterissometimesthisisnotsubjectivelygoodat dealing with largeamount of Gaussian noise as themean filter.

2.1.3 WienerFilter

Theimportantuseofwienerfilteristoreducetheamountofnoisepresentinanimageby Comparisonwithanestimationofthedesirednoiselesssignal.Itisbasedonastatistical approach.Thisfilteringisalinearestimationoftheoriginalimage.Thisfilterisfrequently usedintheprocessofdeconvolution.Theinversefilteringisarestorationtechniquefor deconvolution,i.e.,whentheimageisblurredbyaknownlowpassfilter,itispossibleto recovertheimagebyinversefilteringorgeneralizedinversefiltering.However,inverse filteringisverysensitivetoadditivenoise.TheWienerfilteringexecutesanoptimaltrade-offbetweeninversefilteringandnoisesmoothing[10,11].Itremovestheadditive noise and inverts theblurring simultaneously.
TheWienerfilteringisoptimalintermsofthemeansquareerror.Inotherwords,it minimizestheoverall meansquareerrorintheprocessofinversefilteringandnoise smoothing.The orthogonalityprincipleimpliesthatthe WienerfilterinFourierdomaincan be expressed as follows:

$$G(u,v) = \frac{H*(u,v)Ps(u,v)}{|H(u,v)|2Ps(u,v)+Pn(u,v)} \quad (2)$$

H (u,v)-Fourier spectrum of point spread function
P_s(u, v)-power spectrumof thesignal and
P_n(u,v)-power spectrum of noise.

Itiseasytoseethatthe Wienerfilterhastwoseparateparts,aninversefilteringpart andanoisesmoothingpart.Itisnotonlyperformsthedeconvolutionbyinversefiltering (highpassfiltering)butalsoremovesthenoisewithacompressionoperation(lowpass filtering).

2.2 Resolution Enhancement:

Imageresolutionenhancementinthewaveletdomainisarelativelynewresearchtopicand recentlymanynewalgorithms havebeenproposed.Anotherrecent wavelettransform whichhasbeenusedinseveralimageprocessingapplicationsisstationarywavelet transform(SWT).Inshort,SWTissimilartoDWTbutitdoesnotusedown-sampling, hencethe subbands will havethe same size as theinput image.

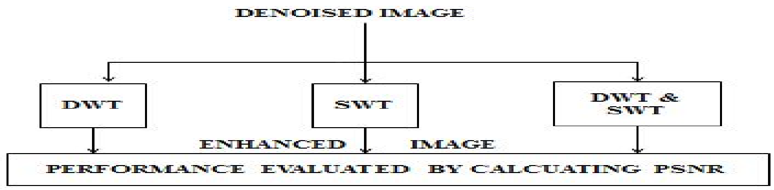


Figure.1 OverviewoftheProposed Work

2.2.1 DiscreteWaveletTransform(DWT):

Discretewavelettransform(DWT)isoneoftherecentwavelettransformsusedinimage processing.DWTdecomposesanimageintodifferentsubbandimages,namelylow-low (LL),low-high(LH),high-low(HL),andhigh-high(HH).Inordertoenhancethe resolutionofanimage,animproveddiscretewavelettransformisusedinadenoised image.TheimprovedDWTpreservestheedgesandthecontour information[12]. In reconstructiontasksithasbeenhamperedbytwomaindisadvantages.1)Lackofshift invariance,whichmeansthatsmallshiftsintheinputsignal,cancausemajorvariationsinthedistributionofenergybetweenDWTcoefficientsatdifferentscales.2)Poordirectionalselectivityfordiagonalfeatures,becausethewaveletfiltersareseparableandreal.Awell-knownwayofprovidingshiftinvarianceistousetheundecimatedformofthedyadicfilter tree.ToovercomethedrawbackofDWT,stationarywavelettransformisappliedtoa denoisedimage.Thebasicideaisextremelysimple,applythehighandlowpassfiltersto thedataateachleveltoproducetwosequencesatthenextlevel.Thereisnodecimation andhencethetwonewsequenceseachhavethesamelengthastheoriginalsequence.The performanceof resolution enhancement techniques is measured using PSNR.

2.2.2 ImageResolution Enhancement using DWT&SWT

In image resolution enhancement byusing interpolation the main loss is on its high frequencycomponents(i.e.,edges),whichisduetothesmoothingcausedbyinterpolation. Inordertoincreasethequalityofthesuperresolvedimage,preserving theedges is essential.Inthiswork,DWThasbeenemployedinordertopreservethehighfrequency componentsoftheimage.TheredundancyandshiftinvarianceoftheDWTmeanthat DWTcoefficientsareinherentlyinterpolable.Inthiscorrespondence,onelevelDWT(with Daubechies9/7aswaveletfunction)isusedtodecomposeaninputimageintodifferentsub bandimages.Threehighfrequencysubbands(LH,HL,andHH)containthehigh frequencycomponents oftheinputimage.Intheproposedtechnique,bi-cubicinterpolation withenlargementfactorof2isappliedtohighfrequencysubbandimages.Downsampling ineachoftheDWTsubbandscausesinformationlossintherespectivesubbands.Thatis whySWT is employed tominimizethis loss.

Theinterpolatedhigh frequencysubbands andthe SWT high frequencysubbands havethe samesizewhichmeanstheycanbeaddedwith eachother.The newcorrectedhigh frequencysubbandscanbeinterpolatedfurtherforhigherenlargement.Alsoitisknown that in thewavelet domain, the low resolution imageis obtained bylow-pass filtering ofthe highresolutionimage.Inotherwords,lowfrequencysubbandisthelowresolutionof theoriginalimage.Therefore,insteadofusinglowfrequencysubband,whichcontainsless informationthantheoriginalhighresolutionimage,weareusingtheinputimageforthe interpolationoflowfrequencysubbandimage.Usinginputimageinsteadoflow frequencysubbandincreasesthequalityofthesuperresolvedimage.Byinterpolating inputimagebyα,andhighfrequencysubbandsby2andintheintermediateandfinal interpolationstagesrespectively,andthenbyapplyingIDWT,[13].Theoutputimagewill containsharperedgesthantheinterpolatedimageobtainedbyinterpolationoftheinput imagedirectly.Thisisduetothefactthat,theinterpolationofisolatedhighfrequency componentsinhighfrequencysubbandsandusingthecorrectionsobtainedbyaddinghigh frequencysub bands ofSWToftheinput image,will preservemore high frequency components after theinterpolation than interpolating input imagedirectly.

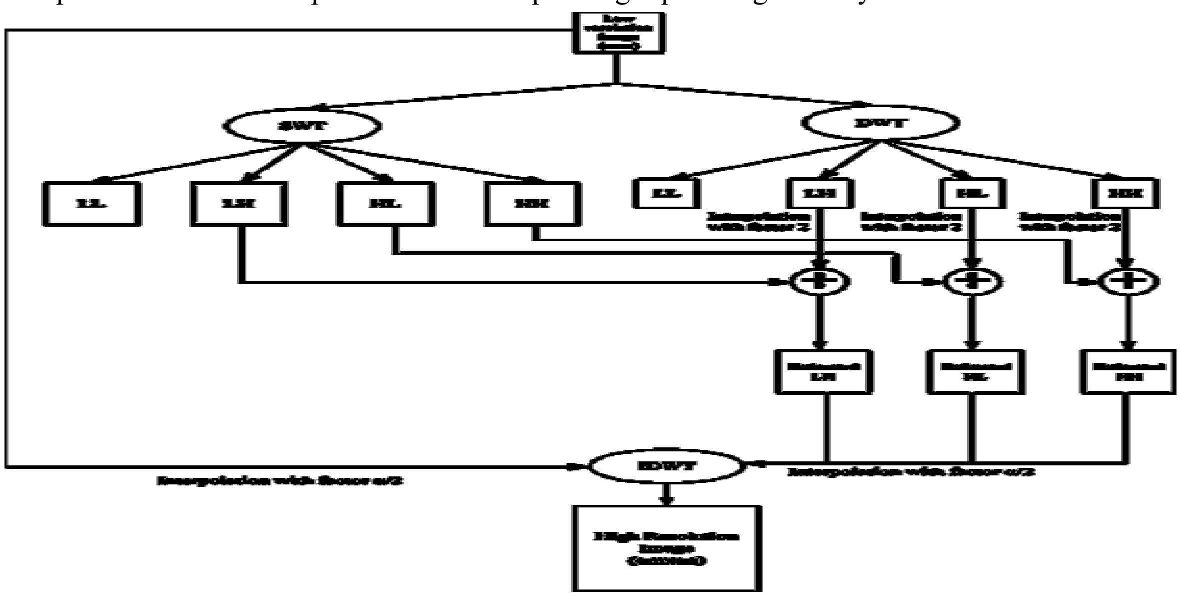
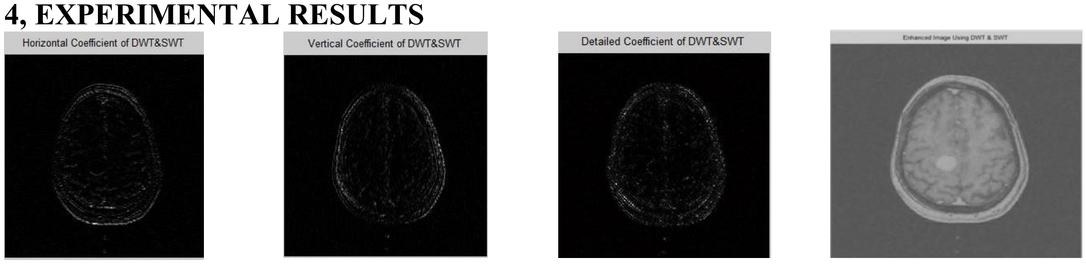


Figure.2 FlowDiagramofthenewEnhancement algorithm

4, EXPERIMENTAL RESULTS



(a) (b) (c) (d)

Fig.3a)HorizontalCoefficientofDWT&SWTb)VerticalCoefficientofDWT&SWT c)Detailed Coefficient of DWT & SWT d) Enhanced ImageusingDWT & SWT

Table 1: Comparison of different Wavelettransforms technique used in our approach.

Transform Techniques	Peak Signal to Noise Ratio
Discrete Wavelet Transform (DWT)	24.1887
Stationary Wavelet Transform (SWT)	13.7554
DWT & SWT	33.1064

V.CONCLUSION AND FUTUREWORK

The MR brain image is pre-processed by denoising and resolution enhancement in order to improve the quality of an image. In denoising, the noise gets reduced better by wiener filtering and the resolution of an image is enhanced by interpolation based discrete wavelet transform which preserves the edges and contour information. The quantitative measure shows that the resolution enhancement technique is having better PSNR compared to the denoised image. This work proposed an image resolution enhancement technique based on the interpolation of the high frequency sub bands obtained by DWT, correcting the high frequency sub band estimation by using SWT high frequency sub bands, and the input image. The proposed technique uses DWT to decompose an image into different sub bands, and then the high frequency sub band images have been interpolated. The interpolated high frequency sub band coefficients have been corrected by using the high frequency sub bands achieved by SWT of the input image. The proposed technique has been tested on well-known benchmark images, where their PSNR and visual results show the superiority of proposed technique over the conventional and state-of-art image resolution enhancement techniques. The future work of this paper is to extract the required features from an enhanced image and to classify the tumors using those extracted features.

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