Comparison between 2D FOURIER TRANSFORM and 2D DISCRETE WAVELET TRANSFORM for denoising the white noise

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ABSTRACT

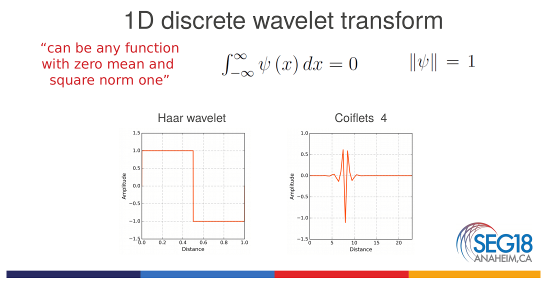
For signal and image processing , removing noise from the data is one of the most challenging task nowadays and extracting valuable information from that as well.So here keeping this in mind I have worked on similar situation of denoising the image where I have take an image of DISNEYLAND and added white noise to it to perform further filtering. After that for filtering purpose we are applying the 2D FOURIER TRANSFORM and 2D WAVELET TRANSFORM ,in spectral domain for filtering the data and both these techniques can be applied to any kind of data be it image or anything else .

Lastly we compare these two filtering techniques on the basis of some performance measures that which performs better or which is more efficient in terms of denoising the image based on the results they produce and some kind of quantitative and qualitative analysis discussed in the relevant papers.

PROJECT INTRODUCTION

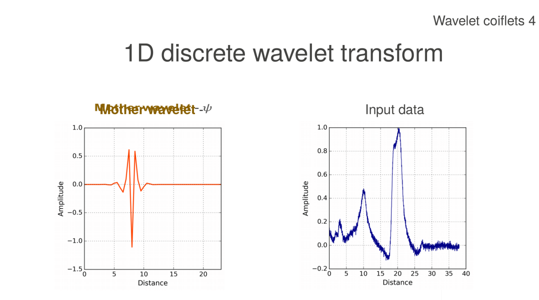
Discrete wavelet transform (DWT) is a valuable tool in signal and image processing, in particular for denoising. It's performance in denoising potential-field data has been proven to be superior to that of traditional techniques discussed in many of the research papers earlier. We analyze the most common thresholding techniques used in DWT : soft and hard thresholding with cycle spinning, for denoising the magnetic data.

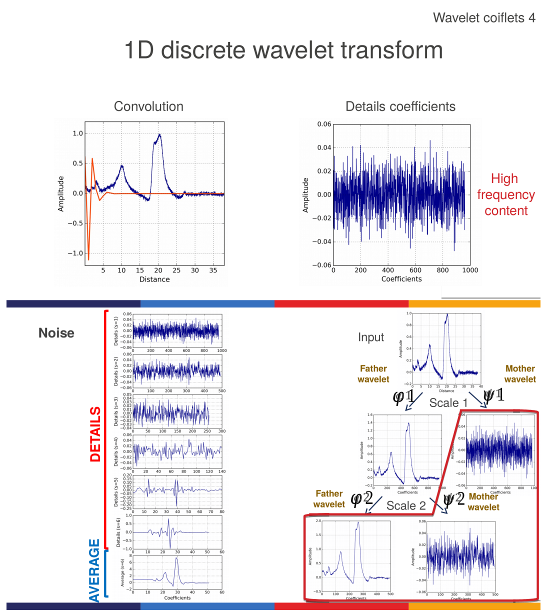
The white noise that we ourselves add to the data is a random noise that fluctuates and changes it's value each and every time upon being added.Fourier transform is applied for filtering purpose but it has some limitations regarding the correlation property , frequency band in the transformed domain with respect to the time/space domain. Namely, the noise cannot be that efficiently removed by Fourier domain filtering that's why we switch to wavelet transform which indeed performs better and overcomes all these limitations exhibited by fourier transform by allowing the decomposition of the data into a linear combination of scaled and translated versions of the basic wavelet also known as mother wavelet.



I selected this topic because dealing with noise that too random noise which in my case I have taken is a challenging task also I wanted to see the comparison between two main different transforms like how well they perform and how much reliable they are in reducing the amount of noise , so I decided to come up with a project that not only filters or deals with the taboos of random noise but also shows the comparison between the two important techniques applied that to in the transformed/spectrum domain. TERMINOLOGIES

The wavelet transform is a multi-resolution technique that is used to decompose the data into its constituent frequencies, here we are using 2D transform which is basically a combination of 1D transform applied both along row and column vectors that is along the x and the y axis in case of an image which is a 2 dimensional data. It is based on the wavelet function or mother wavelet, which can be any function with zero mean and square norm equal to one. For each wavelet, we can build its associated wavelet family consisting of the original wavelet function dilated (or scaled) by the some factor j and translated by other factor k. Any function or data, provided that it is smooth enough, can be decomposed as the linear combination of the elements of the wavelet family:





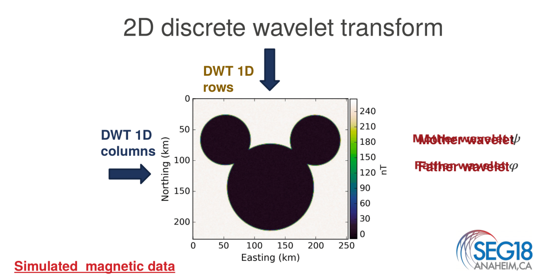
ORGANISATION

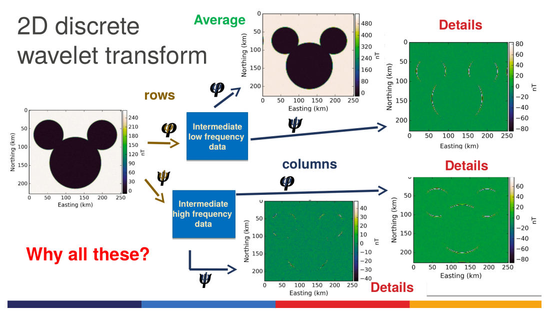
Section 1 – Deals with the dataset that I am utilising for this project.

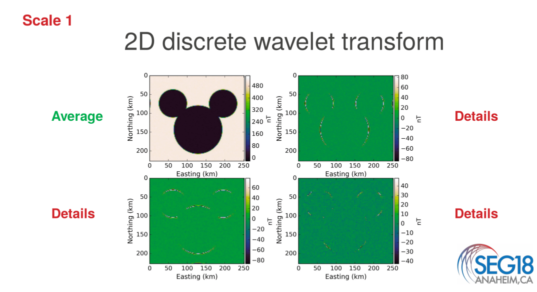
Section 2 – Contains all the literature , all the previous amount of work done , what new has been proposed in this paper.

Section 3 – Contains about methodology , what all formulations have been done , what all mathematics is involved the advacements , new research if done any .

Section 4 – Is all about conclusion and results of the work done here.







PROJECT DATASETS

For my project, I am using only one image that is of face a a mickey mouse or a disneyland image , which is a black and white that is binary image having two values either 0 or 255.

PROJECT LITERATURE

The referred paper is this in which the evaluation is done on magnetic data. 2D Discrete wavelet transform for denoising magnetic data Felipe F. Melo, Valéria C. F. Barbosa and Yolanda Jiménez-Teja, Observatório Nacional.

In the literature, we can find several works where the DWT is applied to denoise one-dimensional data: for instance, Ridsdill-Smith and Dentith (1999) applied it to a magnetic dataset using hard threshold and Lyrio (2004) employed it on gravity gradiometry data using an adaptive thresholding. For denoising two-dimensional gridded magnetic data sets, Leblanc and Morris (2001) applied the DWT using soft threshold and Fedi and Florio (2003) applied it to decorrugate and remove directional trends using the local threshold parameter with soft thresholding. Fedi et al. (2000) applied the DWT on vertical derivatives of a gravity dataset using the local threshold parameter with soft thresholding and Zhang et al. (2017) applied it to gravity gradiometry data with an adaptive Bayesian threshold and mixed thresholding. In addition to denoising of potentialfield data, some authors applied the wavelet transform to filter undesired anomalies (Fedi and Quarta, 1998; Fedi et al., 2004; Paoletti et al., 2007) and to perform interpretations (Chapin, 1997; Oruç and Selim, 2011; Oruç, 2014).

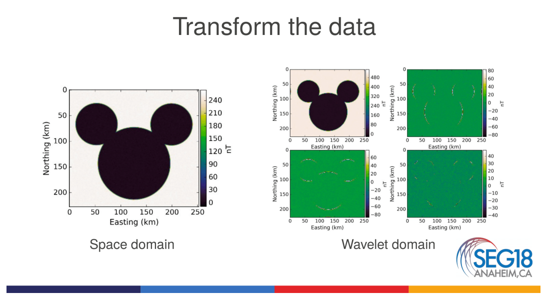
Most of the above-mentioned authors compared the results of DWT with the Fourier filtering, and other techniques for denoising, proving that the DWT performed better in all cases in every aspect. Therefore, in this work, we focus on the use of the DWT with different thresholding methods: soft and hard. For the hard thresholding case, we will consider a variant: the cycle spinning algorithm (Coifman and Donoho, 1995). In the literature, the consequences of using noisy data or improperly denoised data to the interpretation are well known. Therefore, as qualitative quality control for denoising we analyze the input data, the denoised data and the noise. Moreover, quantitative enhancements are measured with the signal-to-noise ratio (SNR) and root mean square (RMS) of the predicted noise. Here, we compare the use of DWT with soft thresholding and hard thresholding using the cycle spinning algorithm for denoising and noise determination. These results also confirm that the DWT with soft thresholding changes the amplitude of the filtered data. So DWT not only overcomes the limitations faced by the naive 2D fourier transform but also individually outperforms with respect to the the qualitative measures and shows effective results for removing noise.

PROJECT METHODOLOGY

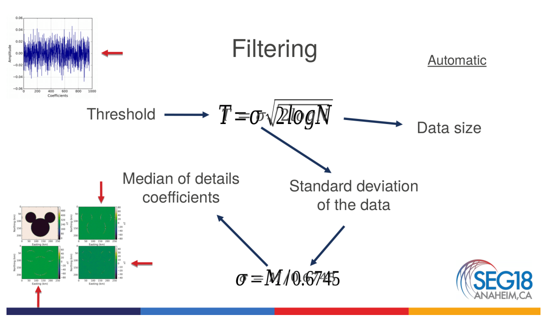
We transform the magnetic data into DWT domain using the PyWavelets . In DWT domain, the threshold is defined in the first details scale and the data is filtered with soft and hard thresholds; the latter with cycle spinning. After filtering in DWT domain, the data is transformed back in space domain with the inverse DWT. The denoised data is evaluated quantitatively and qualitatively to measure the effectiveness of the filtering. As quantitative control of the denoising we compute the signal to-noise ratio and the root mean square of the predicted noise The choice of the wavelet is crucial for DWT filtering . Summarizing, we will proceed as follows:

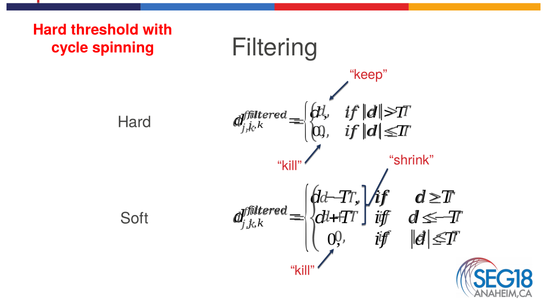
1) Calculate the DWT decomposition
2) Compute the universal threshold
3) Filter the coefficients
4) Apply the inverse DWT
5) Estimate the noise
6) Compute SNR and RMS
7) Analyze the denoised data. Methodology includes 3 main steps

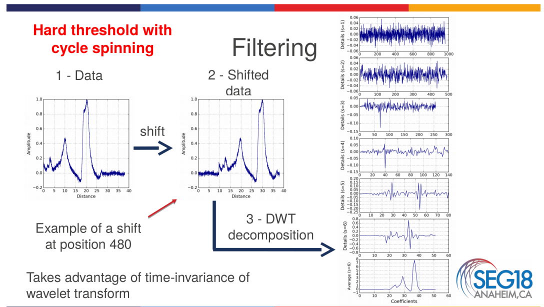
1. TRANSFORM THE DATA



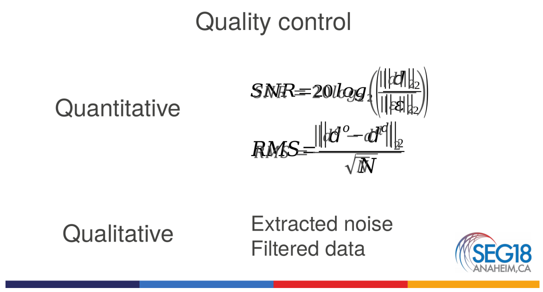
2. FILTERING





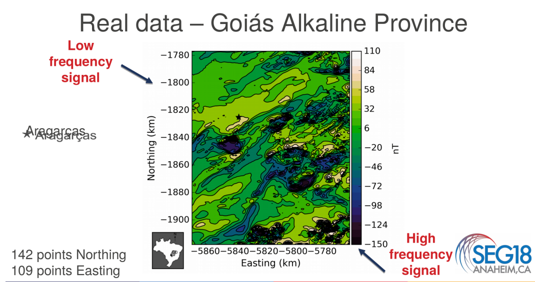


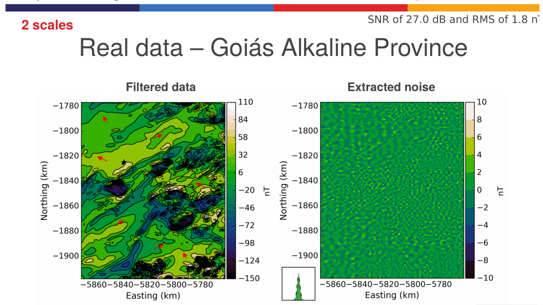
3.QUALITY CONTROL



CONCLUSION

Hard threshold with cycle spinning works fine for 2D magnetic data. Soft threshold extracts data when filtering.Improved real data quality.





2D Discrete wavelet transform (DWT) is a valuable tool for denoising gridded magnetic data. DWT filtering using soft thresholding generates a smooth image, however, it changes the amplitude of the data and this could lead to a wrong quantitative interpretation. On the other hand, DWT filtering using hard thresholding with cycle spinning denoises the data properly and prevents pseudo Gibbs phenomena. The denoised data by applying DWT filtering using hard thresholding with cycle spinning to both synthetic and real data sets gave higher SNR and lower RMS. Moreover, the DWT filtering using hard thresholding with cycle spinning yields removed noise with homogeneous distributions without data that resembles coherent anomalies.

BIBLIOGRAPHY Title : 2D Discrete wavelet transform for denoising magnetic data Author: Felipe F. Melo*, Valéria C. F. Barbosa and Yolanda Jiménez-Teja, Observatório Nacional journal:SEG International Exposition and 88th annual Meeting year:2018.