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دراسة تحليلية لتحويل المويجة في مجال التحسس النائي

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المستخلص

يتناول البحث الحالي دراسة تحويل المويجة بتطبيقه على صورة فضائية باستعمال معاملات Haar و Daubechies (ذات أطوال 4−20 pixel) وتم تحليلها باحتساب النسبة المئوية للمعلومات في الربع ذو التردد واطئ−واطئ ودراسة توزيع النسبة المئوية المعلومات في الأرباع ذات الترددات العالية لمستويات تحلل مختلفة. وتمت دراسة تأثيرات حذف الترددات العالية على نوعية الصورة الناتجة بمقارنتها مع الصورة الأصلية باستعمال المعيار نسبة−الإشارة−إلى−الضوضاء, حيث لم يتم تسجيل أي فرق بين نتائج الصور عند استعمال معاملات Haar او Daubechies.

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An Analysis Study of the Wavelet Transform in Remount Sensing

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Abstract

In this research work a study for the wavelet transform for a satellite image is presented where the Haar and Daubechies (tab 4-20) bases had been analysis by using the percent information in the low-low part and the distribution of the information percent in the high frequency parts for different decomposition levels. The effect of truncation of the high frequency parts on the quality of the resultant image compared with original image presented by using the Signal-to-Noise-Ratio (SNR), where no difference found in the resultant image by using either the Haar or Daubechies basis.

Introduction

During the last years, wavelets have become very popular in the fields of signal processing and pattern recognition and have led to a large number of publications. In the discipline of remote sensing several applications of wavelets have emerged too. Among them are such diverse topics as image data compression, image enhancement, feature extraction, and detailed data analysis. On the other hand, the processing of remote sensing image data - both for optical and radar data - follows a well-known systematic sequence of correction and data management steps supplemented by dedicated image enhancement and data analysis activities. [1,2]

A wavelet, which literally means little wave, is an oscillating zero-average function that is well localized in a small period of time. A wavelet function, known as a mother wavelet, gives rise to a family of wavelets that are translated (shifted) and dilated (stretched or compressed) versions of the original mother wavelet. [3]

Wavelets have great utility in the area of digital signal processing. A digital signal can be represented as a summation of wavelets that are fundamentally identical except for the translation and dilation factors (or coefficients). Hence, a signal can be represented entirely by wavelet coefficients. These coefficients provide important frequency and temporal information which can be used to analyze a signal. Furthermore, the signal can be processed in the wavelet coefficient domain before being transformed back to the normal time-amplitude representation. Thus, wavelets facilitate a unique framework for digital signal processing. [3]

The location covers the Baghdad International Airport, Baghdad, Iraq; the image was collected multispectral image using IKONOS satellite had been used in this research as shown in figurer (1).

Wavelet Transform

The wavelet transform is a fine-grained approach that seeks to achieve an optimal balance between frequency resolution and time resolution. At higher frequencies, the transform gains temporal information in exchange for a loss in frequency information, while at lower frequencies, the transform gains frequency information in exchange for a loss in temporal information. This fine-grained approach in handling the tradeoff is useful for digital signal and music applications, since transients normally occur at high frequencies (thus needing a higher time resolution), and lower frequencies usually require a higher frequency resolution. The wavelet transform can be represented as in the following form:

$$Wx(u,s) = \int_{-\infty}^{\infty} x(t)\Psi_{u,s}(t)dt \qquad \ldots(1)$$

In the above integral, the input signal x(t) is correlated with the wavelet with translation parameter u and dilation parameter s [4]. This transform converts a signal into coefficients that represent both time and frequency information, with more time resolution at high frequencies, and more frequency resolution at low frequencies. [3]

One fast way of computing a wavelet transform is with a cascade of filters [4]. The input signal is fed into two filters, H and L. The filters produce two sets of coefficients which are both down-sampled by a factor of 2. As shown in Figure 2, this procedure is recursively applied to the set of coefficient that comes out of the H filter. One assumption of the wavelet transform is that the number of samples in the input signal is a power of 2. If the number of samples is not a power of 2, the signal can be zero-padded to achieve this criterion. [3]

HAAR Wavelet Transform

The Haar wavelet, which Alfred Haar discovered in 1910, is both powerful and pedagogically simple. The basic Haar wavelet is a piecewise constant function that is defined as follows [5]:

$$\Psi_{[0,1]}(r) = \begin{cases} 1, & 0 \le r < \frac{1}{2} \\ -1, & \frac{1}{2} \le r < 1 \\ 0, & otherwise \end{cases} \qquad \ldots(2)$$

Daubechies Wavelet

Named after Ingrid Daubechies, the Daubechies wavelet is more complicated than the Haar wavelet. Daubechies wavelets are continuous; thus, they are more computationally expensive to use than the Haar wavelet, which is discrete [5].

Results and Discussion

Numerous filters were introduced to implement the wavelet transform. Two wavelet filters are used in this research, Haar filter and Daubechies filter for tabs 4, 6, 8, 10…20. The decomposition preformed by using pyramid decomposition scheme to perform more than one decomposition level. The information that contained in the LL part compared with the other parts is calculated by using the following equation:

$$Information\ Percent in\ LL = \frac{\sum |LL|}{\sum |All\ Parts|} \quad \ldots(3)$$

By applying eq. (3) on the tested image, the information percent that contained in the LL part (IPLL) for different decomposition levels (1-7 decomposition level) are shown in the figure (5).

The IPLL decrease exponentially with decomposition level for Haar filter while it decreases linearly with decomposition level for Daubechies filters. The IPLL has the same value for both filters for the first decomposition level but it separate at the second decomposition level where the IPLL decrease very quickly in exponential manor for Haar filters reaching very low values (about 10% of the whole transform information). While for Daubechies filter and due to the overlap property for the filter coefficients which allow the filters coefficients to absorb more information in the LL part, the IPLL decrease slowly by compare with Haar filter in linear manor, with more decomposition the IPLL decrease but stay over the 40% for all possible decomposition levels.

To evaluate the amount of information in the high frequency parts in each decomposition level, the IPLL for each level had been subtract from the previous IPLL to obtain the information percent in the high frequency part in the previous level, figure (6) illustrates the information percent in the high frequency parts for different decomposition levels.

For Haar filter, the information percent in the high frequency parts increases with decomposition level until the third decomposition level where the information percent start to decrease indicating that the LL part after the third decomposition level start to deplete of the high frequency. While for the Daubechies filters the information percent decreases with the decomposition level in linear manor, indicating that with each decomposition level the high frequency parts still exist in the LL part but it will contain less information compared with the previous decomposition level.

To evaluate the contributing of the high frequency parts in the reconstructed image, the test image reconstructed in absent of the high frequency parts depending only on the LL part for different decomposition level and compared with the original image by using signal-to-noise ratio as depicted in figure (7).

In spite of that the Haar filter differ from the Daubechies in distributing the information in the high frequency parts for different decomposition level but all filters have the same behavior when eliminating the high frequency parts, with one advantage that the images that reconstructed by using Daubechies filters do not suffer from the block artifact like that reconstructed by using Haar filter due to the overlap property that Daubechies filters have.

Conclusions

With the previous analysis of the wavelet transform by using satellite image of Baghdad international airport by using Haar and Daubechies filters for different decomposition level, the following conclusions and recommendation can be made:

- The wavelet transform dose not extract all the high frequencies in the first decomposition level, this is obvious when we apply the transform for more decomposition levels, the high frequency parts will show more information in the new decomposition levels which prove that the LL frequency part did not successfully eliminate all the high frequency even when applying the transform for more than one level.
- Due to overlap property and For a certain decomposition level, the LL part that obtained by using Daubechies filter contain more information than in the LL part that obtained using Haar filter.

- when the high frequency parts are the target of the wavelet transform in order for altering process, the third decomposition level are recommended for Haar filter and the first decomposition level for Daubechies for different tabs.
- Using different tabs have insignificant effect on the distribution of the high frequency part, and tab6 or tab8 are fair since they have the higher IPLL and selecting higher tabs will cost more computation time.
- The advantage of using Daubechies filters in wavelet transform is illuminating the final product from the block artifact that Haar filter suffer from when we alter the wavelet coefficients.
- High frequency parts play major rule in the wavelet transform, and ignore them in the reconstruction step will reduce the final image quality significantly, therefore the LL part cannot be considered as a compressed version of the original image.

References

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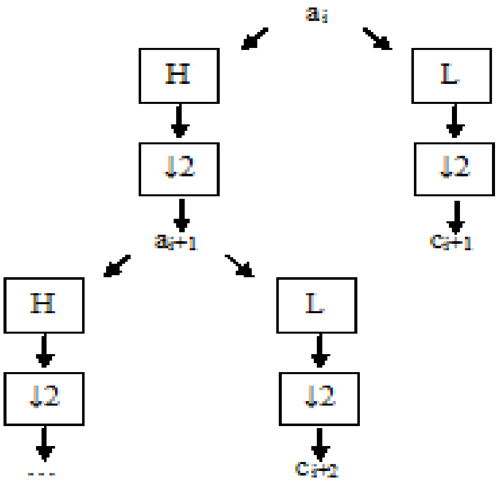
Figure (1) the scene of Baghdad Internationals airport



Figurer (2) the high and low wavelet filters

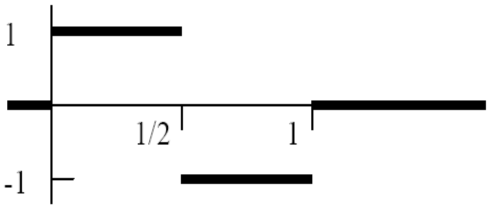


Figure (3) Haar Scaling function

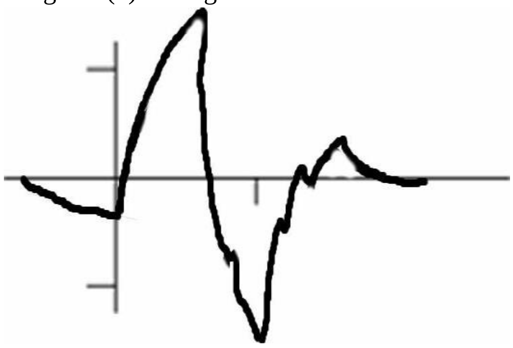


Figure (4) Daubechies scaling function

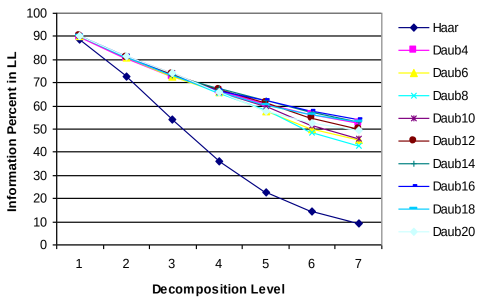


Figure (5) the information percent in the LL part for different decomposition levels

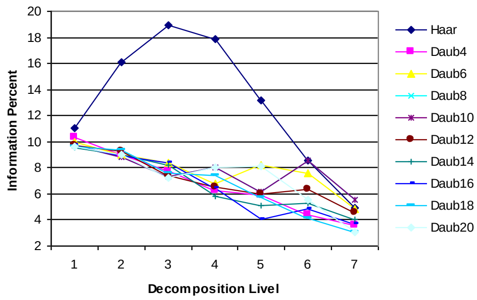


Figure (6) the information percent in the high frequencies parts for different decomposition levels

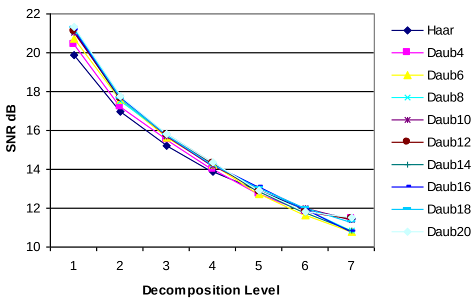


Figure (7) the restored image quality after truncating the high frequencies parts for different decomposition levels.