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The Research of Heuristic Algorithm of Wavelet Image denoising based on Rough Set

Song Lan[1,2]
[1]Information and Engineering College, East China JiaoTong University, Nanchang 330013, Jiangxi, China
[2]State Key Laboraory of Software Engineering,Wuhan University, Wuhan 430072,Hubei,China
e-mail:sl130com@gmail.com
Lei Lixia
Information and Engineering College, East China JiaoTong University, Nanchang 330013, Jiangxi,China
llx163@163.com
Li Haisheng
Information and Engineering College, East China JiaoTong University, Nanchang 330013,Jiangxi, China
e-mail: lhs@ecjtu.jx.cn
Hong Wang
Nanchang city sports bureau, Nanchang 330000,Jiangxi, China

Abstract. By using Rough Set Theory and the concept of attribute significance, the paper analyzes the approximate and detail component at different scales got by the wavelet transform of the original image, then adopts a knowledge-reduction-based algorithm according to its importance in the signal classification, finally extracts the wavelet energy which is the most sensitive to signal characteristics in order to achieve adaptive threshold selection and the smooth denoising of image. Simulation experiments prove that this method can achieve better effect.

Keywords: Image denoising; Rough set; Wavelet coefficient; Threshold

1 Introduction

The original image collected in the actual project contains a certain amount of noise. The noise-contained image is of poor quality, so it fails to reflect the information contained in real image. Removing the noise is a critical technology of wavelet image processing[1]: the wavelet transform can decompose the image signal into characteristic coefficients with different resolutions and the latter can then be analyzed and processed in order to remove noise. In the year of 1994, Donoho and other scholars [2-3] put forward the wavelet shrinkage algorithm for image denoising. It can achieve the goal of image denoising by removing the wavelet coefficient which is less than a certain threshold. The most commonly-used method is to remove or reduce

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these high-frequency coefficients in the transform domain, and then inverse transform to get the image, so as to achieve the purpose of denoising[4].

The estimate of the threshold is a key issue of the wavelet threshold algorithm for image denoising. If the threshold is too small, the noise will still exist in denoised image. On the contrary, if the threshold is too big, some important image features will be filtered out. In practical project, Hard Threshold[2], Soft Threshold[3] and other methods are usually used to determine the threshold. With a certain amount of guesswork, these commonly used methods tend to have an unstable effect of denoising.

As a measurement of the attribute significance, Rough Entropy deletes irrelevant or unimportant knowledge on the condition that the classified or decision-making ability of knowledge database remain unchanged[5-6], so as to achieve the purpose of knowledge reduction. As the Rough entropy of knowledge decreases monotonically with the enhanced ability to distinguish, we can set the adaptive threshold value of the transformed image's wavelet coefficients.

By using Rough Set Theory and the concept of attribute significance, this paper analyzes the approximate and detail components at different scales got by the wavelet transform of the original image, then adopts a knowledge-reduction-based algorithm according to its importance in the signal classification, finally extracts the wavelet energy which is the most sensitive to signal characteristics in order to achieve adaptive threshold selection and the purpose of image denoisng. The results of the simulation experiments prove that this method can achieve better results.

2 The heuristic algorithm of wavelet denoising based on Rough Entropy

First, we carry out the multi-scale wavelet transform of image , analyze the different-characterized wavelet coefficient (a coefficient in scale) by taking the noise into consideration, conduct the different degrees of separation between high-frequency component and low-frequency component in the original image by using the wavelet decomposition, then extract the wavelet energy which is the most sensitive to the characteristics of image by using the Knowledge Reduction Theory of Rough Set, finally improve the image effect by using the method of wavelet reconstruction after setting the corresponding threshold processing function and processing the noise.

The wavelet coefficients energy in scale J is defined as , and the total energy of image is defined as .

The new processing function of wavelet soft threshold is as follows:

(8)

Of which

(1) shows the correlation between the entropy and the processing function of wavelet coefficient threshold; and represents the decomposed wavelet coefficient and the corresponding denoised wavelet coefficient respectively.

(2) Threshold represents the threshold of wavelet coefficient in layer J.

(9)

(3) the variance of the estimated value

(10)

is the set of detail wavelet coefficients with the smallest entropy value after the conversion of the first layer.

By using the measurement of the attribute significance in the Rough Set Reduction Theory given, we can extract the wavelet coefficient which is the most sensitive to the characteristics of images. In this section, the writer puts forward a heuristic algorithm. Its basic idea is as follows: it regards the approximate decomposed wavelet coefficient as the core attribute, calculates the importance of the inter-cell component of wavelet coefficient to the core attribute, then find out the maximum value and classified it as a member of the core attribute, eventually realized the reduction of attribute set.

Algorithm:
Input: a decisional table T={U,C∪D,V,F}, of which, U is the domain of discourse, C and D are the conditional attribute set and decisional attribute set respectively.
Output: a relative reduction of the decisional table
Step 1: dividing the transformed wavelet coefficient into several small sections. The coefficient of the whole sections is regarded as the set of conditional attribute C.
Calculating the entropy of each small section. are the wavelet coefficient energy in different sections.
Step 2: regarding the decomposed low-frequency wavelet coefficient as the core attribute B, Att=C- B.
Step 3: if E(B)~kE(C), then
begin
①For each attribute $a_j \in$ Att, calculate the Rough entropy E(B∪{a_j})of decisional attribute D with respect to the conditional attribute set B∪{a_j}
②Choose the attribute with the maximum value of E(B∪{a_j}) in Att, Att=Att-

{a},B=B□{a}

③If E(B)=kE(C), then move on to Step 4; otherwise, move on to Step 1

④ Output a reduction B of decisional table.

end

The algorithm sets the core attribute set of decisional table as a starting point, adds successively the non- core attribute A which makes the minimum value of E(B□{a_j}) to the core attribute set until it satisfies the termination condition E(B)=kE(C), finally get the reduction results.

Given the worst case, the number of attributes is n,n-1,□,1 (n is the number of wavelet coefficient), the total number is n+(n-1)+ □+1=n(n+1)/2. Therefore, in the worst case, this algorithm can help to find a satisfactory reduction in the $0(n^2)$ time complexity.

3 Simulation Experiment

We simulated this algorithm in order to verify the effectiveness and feasibility of this algorithm, the experiment takes the lena image, Barbara image with the size of and the grayscale of 256 as the original image, adds a normal random noise with the standard deviation value of 20 to the original image next, then conducts multi-wavelet decomposition and the denosing of wavelet coefficient's adaptive soft threshold, finally reconstructs the image. The experimental results are shown in figure 1:

(a) the original image (b) noise-added image (c) NLM denoising method (d)the denoising method

Fig. 1. The effect picture of lena image denoising

Figure 1 shows the reconstructed image of denoised lena image. Of which, Figure (a) is the original image, Figure (b) is the noise-added image, Figure (c) is the denoised image. As can be seen in Figure 1, compared with NLM denoising method, this method better preserves detail and texture information, effectively removes the noise of image, and improves the quality of image as it adopts the rough entropy attribute importance model and makes full use of information from multiple wavelet direction.

This paper adopts PSNR (Peak Signal to Noise Ratio) as a comprehensive evaluation index of denoising performance. The gaussian noise with the standard deviation of 5, 10, 15, 20, 50 are added to the test images "Lena" and "Barbara". By adopting the NL Method and our method respectively, the statistical results of denoised PSNR are shown in table 1.

As can be seen from the table, after comparing the application of NLM algorithms to different images and noise, we found that it is feasible to calculate the similarity of high-frequency range of quantum by using Rough entropy attribute importance model, which prove to be having certain denoising effect. This paper puts forward the importance measurement model of Rough entropy and the importance reduction method of wavelet coefficients; combines rough set with thresholding method; and makes full use of lots of redundant information in natural images. On the basis of the importance model, this paper reduces those collections with high-level similarity and combines them effectively by making rational use of wavelet information from multiple directions, thus achieving certain denoising effect.

Table 1. The comparison of two thresholds' denoising method PSNR

image	method	5	10	15	20	50
Lena	Our method	38.05	35.43	33.73	32.46	27.85
	NLM method	37.73	35.38	33.64	32.26	27.49
Barbara	Our method	36.97	34.29	32.39	31.03	25.61
	NLM method	36.54	34.12	32.23	30.80	25.62

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