A Novel High Resolution Image Denoising Algorithm Based on Calman Filter and Texture Feature Extraction

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Abstract

Calman filtering method based on wavelet transform has been successfully applied to signal denoising. According to the different application methods and the realization forms of Calman filter, combined with the structural analysis of wavelet decomposition, we present kinds of multi-scale filtering methods into the category of the three. The simulation results show that the multi-scale Calman filtering method based on system layer has better performance. Synthetic aperture radar (SAR) images have rich texture information, which can reflect the spatial structure of objects. The texture feature is widely used in SAR image classification and SAR image segmentation. Affected by imaging factors, the direct use of texture features extracted from SAR images is not good enough. In order to avoid the traditional method of filtering followed the texture feature extraction caused by the loss of texture and edge information, this paper presents a texture feature extraction of SAR image, then using Robust PCA method, finally using texture feature clustering method K-means test after treatment with RPCA expression.

Keywords: Calman filter, texture feature, high resolution image, image processing, image denoising

Introduction

In this paper, based on the multi-scale Calman filtering state equation and observation equation forms of wavelet decomposition structure of the multi-scale Calman filter used in image denoising is divided into three categories, we decompose layer, layer and system layer reconstruction of Calman filter concept [1-5].

The Calman filter is extended to two-dimensional space, and can be applied to image denoising. But for the image with low contrast, blurred edge and large background fluctuation, the application of Two-Dimensional Kalman (2DKF) in the process of image processing can easily lead to the loss of important information such as details and edges and how to ensure the protection and enhancement of the detail information in the process of image filtering, and effectively filter the noise has been a hot issue in the fields. On the other hand, fractional calculus can be applied to image processing, which can effectively enhance the texture features of the image. However, the above methods can enhance the image and reduce the signal to noise ratio.

SAR image using radar to transmit and receive scattered electromagnetic echo imaging. The SAR image has been widely used in military and civil fields because of its all-weather working characteristics. With the rapid enhancement of SAR image data acquisition, the amount of data is increasing rapidly, and the manual interpretation cannot meet the needs of the application. Therefore, computer aided interpretation has become a hot research topic. As the abstract description of image, feature is the basis of classification, recognition and retrieval in SAR.
image automatic interpretation. Echo signal imaging SAR dependent objects, while the intensity and phase of echo signal with different features of location and spatial structure have significant differences, these differences caused by gray spatial distribution with different feature information, so the SAR image has rich texture information [6-7].

At present, the feature extraction of SAR image based on texture feature is generally faced with the problem of how to deal with the speckle. At present, the general method is to filter the SAR image before extracting the features to suppress the speckle. But this way will be to a certain extent on the edge of the original image and the texture of losses, this is because the filtering operation mostly adopts the sliding window, a window in the area, the mean and variance based on different criteria to adjust the center pixel value is the average, to a certain extent, resulting in edge and small texture loss.

![Figure 1. Different types of SAR images have different texture.](image)

**The Proposed Methodology**

**Multi-scale Calman filtering.** For the sake of illustration, we first give the block diagram of the orthogonal wavelet transform filter banks (QMF) decomposition and reconstruction. The decomposition and reconstruction are three layers.

![Figure 2. QMF decomposition and reconstruction filter.](image)

Calman filter is the simplest form of the application of the wavelet transform in the wavelet domain of the decomposition of the filter in the form of the decomposition of the layer of the. Calman refers to the Calman decomposition layer filter is mainly in the wavelet decomposition layer, system state equation and measurement equation reflects the change of signal and measurement in a decomposition scales. The main idea is that the wavelet coefficients at different scales are noisy, so it can be for each layer using Calman filter to get the estimation of the original signal wavelet coefficients. Finally, wavelet reconstruction by signal denoising. In other words, the decomposition of Calman filter in each layer wavelet decomposition of the Calman filter is still a standard, the only difference is that filtering occurs in the wavelet domain.
instead of the time or space domain, at the same time, Calman will be the hidden layer decomposition filter scale state equation as the independent assumption [8-9].

For Calman filter, the multi-scale state space model and the measurement equation are as follows:

\[ x(i, k + 1) = A(i)x(i, k) + w(i, k) \]
\[ z(i, k) = C(i)x(i, k) + v(i, k) \]

Different from the Calman decomposition layer filter, Calman filter layer based on the sparse reconstruction from the scale to refine the scale recursive equation as state space model, so as to make full use of the correlation coefficient between scales. The measurement equation is the same as that of the Calman filter, which represents the measured value of the signal at a certain scale.

The multi-scale state space model and the measurement equation of the reconstructed Calman filter are as follows:

\[ x(i, k) = A(i)x(i + 1, k\gamma) + B(i)\omega(i, k) \]
\[ z(i, k) = C(i)x(i, k) + v(i, k) \]
Texture based method. RPCA is a signal processing method based on compressed sensing and sparse representation theory. It overcomes the problem that the traditional PCA can only recover the matrix which is interfered by the smaller and more dense Gauss noise, and can recover the matrix of the interference of the non Gauss noise. It has been widely used in the field of visible light image and video denoising and restoration.

The same kind of SAR target image is often not the same texture distribution background, because of the lack of consistency in the background, the slice can not be aligned, so it can not form a low rank matrix. Although the slice images of the same scene have similar gray level distribution, it is difficult to meet the conditions of the low rank matrix when the slices are different. But the features extracted from the same object, the theory can express the same scene or object, so the structure of similar or the same characteristics, and thus has a strong correlation, which can form a low rank matrix [10-11].

Figure 5. RPCA Texture feature.

Figure 6. The mean of texture feature of 3 kinds of slice samples processed by RPCA.
**K-means clustering.** In order to further test the ability of distinguishing the texture features of RPCA images, we compare the texture features of the samples with RPCA before and after the treatment. We use K-means method to cluster all the samples. K-means is a commonly used clustering method. After the RPCA treatment of the characteristics of the cluster, the indicators have been improved, which shows that the image texture feature differentiation ability has been enhanced.

Texture feature based on gray level co-occurrence matrix is an important method to represent SAR images, which has important application in SAR image segmentation and classification. In this paper, after extracting the texture features of GLCM, RPCA is used to denoise the texture features, and then to improve the representation ability of GLCM features. The experimental results on TerraSAR-X data show the effectiveness of the proposed method. At the same time, we also noticed that there are some improvements in the experiment, we can try to combine multiple features to improve the clustering effect.

**Conclusion**

In this paper, based on the texture features and Calman filtering theory, the discrete state space of the Calman filter algorithm is proposed. Calman filter is used to process the image with noise. The algorithm can effectively reduce the background noise in the image and enhance the details of the image. Calman filtering technique has been applied to signal processing in wavelet domain. The simulation results show that the Calman filtering method based on the system layer has the best denoising performance because of the better use of the correlation between the wavelet coefficients in scale and scale.

**References**


