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Reduction of Signal Noise from Hyperspectral Images Using Multijoint Methods

Sivaranjani.V [1], Suruthi.S [2]

P.G. Student, Department of Communication Systems, Dhanalakshmi srinivasan Engineering College, Perambalur, Tamilnadu, India[1]

Associate Professor, Department of Communication Systems, Dhanalakshmi srinivasan Engineering College, Perambalur, Tamilnadu, India[1]

ABSTRACT*:* To remove the noise from hyperspectral images for efficient target detection. The noise introduced into the image, when the distribution of spectral content disturbed. Here two type of noise are present in an image which are signal dependent and independent noise. This noise completely removed by multijoint method. The parallel factor analysis effectively remove the white noise that present in an image. So parallel factor analysis (PARAFAC) decomposition, twice to remove SI and SD noise, respectively. The adaptive filter alternatively remove both signal dependent and independent noise. So most of the noise eliminated by the adaptive filter. This method effectively working even in high noise. This research improve the target detection by eliminating the noise.

KEYWORDS: Hierarchical clustering, HyperSpectral Image (HSI), Parallel Factor Analysis (PARAFAC), Signal-Dependent (SD) noise, Signal-Independent(SI).

I. INTRODUCTION

Hyperspectral imaging is the process of capturing images of a scene over multiple bands of the electromagnetic spectrum. Hyperspectral image data are collected by sensors on aircraft or satellites mainly in digital format. These image data contain errors that can be classified into three categories which are atmospheric, instrumental, and geometric distortions. The correction of atmospheric effects is called atmospheric calibration. The modeling approach for atmospheric calibration of hyperspectral images often makes use of the image data themselves. Instrumental errors are mainly in the form of banding or striping. Banding is typically a visible noise pattern caused by memory effects. Additionally, improper spectral alignment between the entrance slit and the detector array induces noise in images collected by a linear scanner. These type of noise are effectively reduced by multijoint method. The adaptive filter is effectively remove both colored noise and white noise present in the SI noise. Finally SD noise removed by PARAFAC method. The hierarchical clustering need to split the image into group of pixels. The threshold value set to remove the noise.

II. NOISE REDUCTION METHODS

A. Adaptive Filter

The adaptive filter can remove both white and coloured noise which present in an image. In our project, primary input is an image. This image contains both signal and noise denoted as s+n. Here the reference input is noise source, the salt and pepper noise externally added into the image. So the adaptive filter find the error estimation and eliminate the noise.

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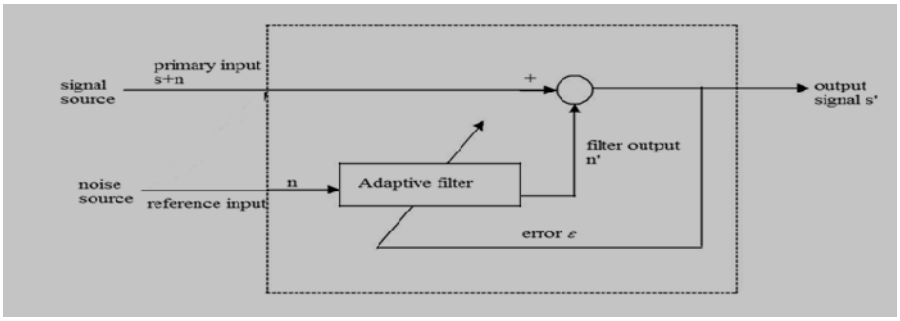

Fig.1.Adaptive noise cancellation filter

$s'^2 = s^2 + (n - n')^2 + 2s(n - n')$ _____(1)

$E[s'^2] = E[s^2] + E[(n - n')^2] + 2E[s(n - n')]$

$= E[s^2] + E[(n - n')^2]$ _____(2)

$\min E[s'^2] = E[s^2] + \min E[(n - n')^2]$ ____(3)

Minimize $E[s'^2]$, $E[(n - n')^2]$ also minimized

$(s' - s) = (n - n')$

$(s' - s) = 0$

$s' = s$_____(4)

This filter used to remove the noise without having the prior knowledge about the noise characteristics. So the both SI and SD noise to be eliminated effectively.

B. Stochastic gradient approach

The most commonly used the adaptive filter to remove noise from an image signal. Adaptive filter algorithm are splinted into two method. First method named as LMS in terms of least mean square and another is RLS expressed as recursive least square. In our research least mean square algorithm are used to improve the signal to ratio. To reduce the error must define cost function as mean-squared error. Difference between filter output and desired response to improve signal to noise ratio. The least mean square algorithm done by coefficient that is found by steepest descent. It requires the gradient of the error surface to be known. Most popular adaptation algorithm is LMS that is derived from steepest descent.

$$\begin{pmatrix}\text{update value}\\ \text{of tap - weigth}\\ \text{vector}\end{pmatrix} = \begin{pmatrix}\text{old value}\\ \text{of tap - weight}\\ \text{vector}\end{pmatrix} + \begin{pmatrix}\text{learning -}\\ \text{rate}\\ \text{parameter}\end{pmatrix}\begin{pmatrix}tap-\\ input\\ vector\end{pmatrix}\begin{pmatrix}error\\ signal\end{pmatrix}$$

C. Hyperspectral noise estimation

The noise present in image after the PARAFAC method can be effectively removed b using HYNE method.

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III. BLOCK DIAGRAM

The block diagram of noise elimination is given below. First step to collect the hyperspectral image from satellite. From that image find the required target. Due to the spectral distortion in the image cause noise. So the two types of noise should be eliminated.

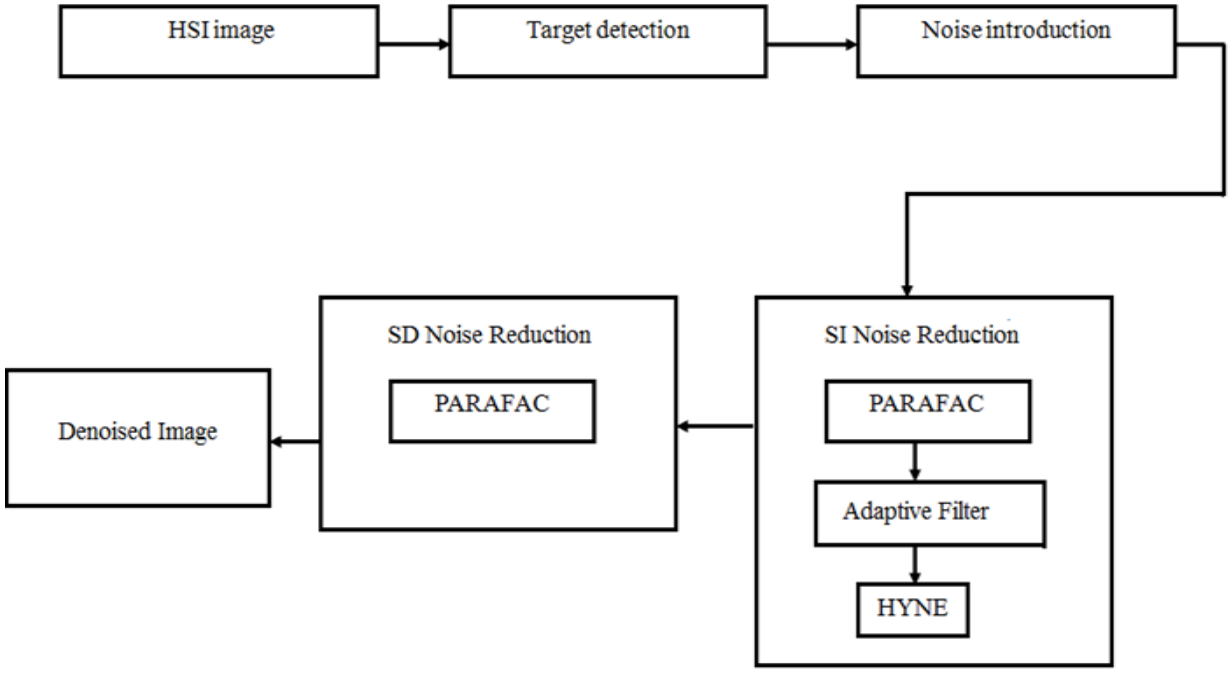

Fig.2. Block diagram of noise elimination

The signal independent noise removed by parallel factor analysis. This is used to split the image into two part called us Split-half analysis. It is very much useful to remove white gaussion noise. During the noise removal only a lowest loss of signal. The adaptive filter technique is used to remove the noise without having prior knowledge about noise. This filter alternatively remove both signal dependent and independent noise.

IV. RESULTS

The output shown below presents the simulation output of different noise elimination mathods. The selected image for the noise elimination is selected. The blurred image and hyperspectral image for target identification shown below.

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Fig.3. Selected image with noise

The image with blur and noise are shown here. The salt and pepper noise added to the image for estimating the noise elimination. After that image to be registered to eliminated with adaptive filter and PARAFAC.

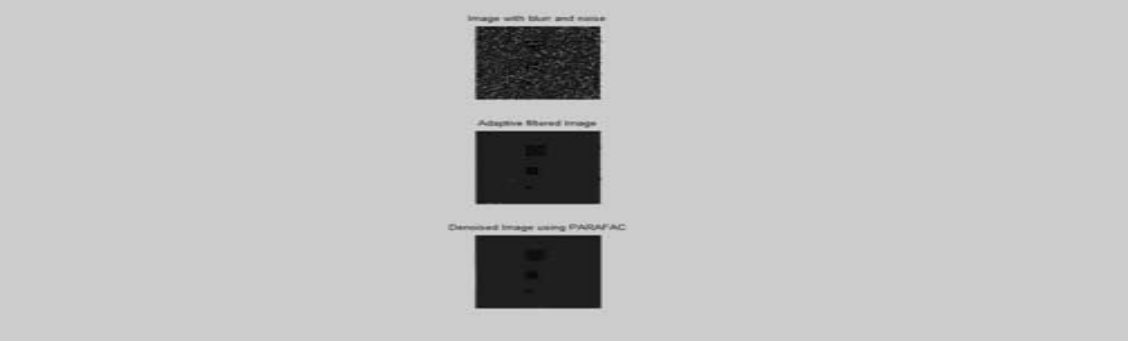

Fig.4. Reduction of noise

After the removal of SI and SD noise the recovered image shown in below. First SI noise to be removed. After that both SI and SD are removed. The three target output is obtained, which is given in below. The spectral content are increased with high signal to noise ratio of 41.453. The both background and three different target are detected and plot below.

Fig.5. Reduction of SI and SD noise

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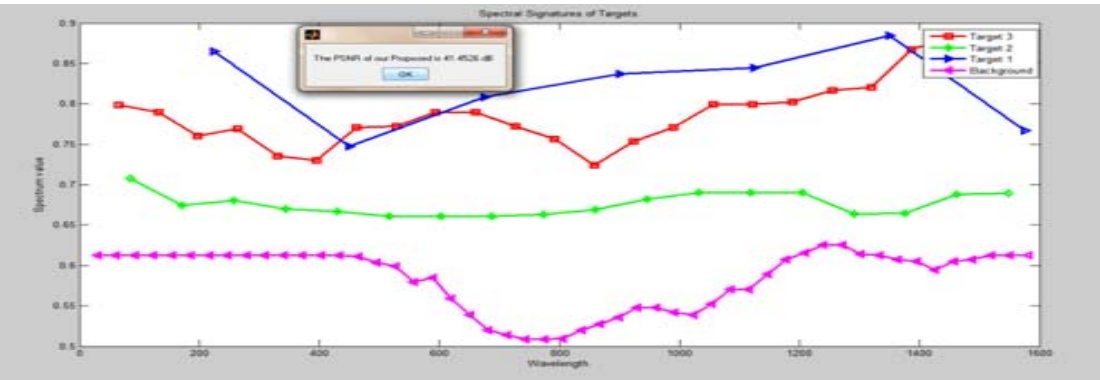

Fig.6. Target detection

V. Conclusion

To reduce both SD and SI noise, we have proposed three tensor-based methods that consist of two steps. The parallel factor decomposition used to remove the white noise. The adaptive filter alternatively remove both signal dependent and independent noise. So most of the noise eliminated by the adaptive filter Then to reduce the residual SD components PARAFAC decomposition is applied to the denoised HSI by the previous step. The hierarchical clustering used to divide the image into 30 parts. We already set the threshold value. The below threshold value pixels consider as a noise and to be eliminated. The performance of the proposed PARAFAC-SI, PARAFAC- SD, HYNE-PARAFAC, and Adaptive filter-PARAFAC methods is validated on the simulated HSIs distorted by both SD and white SI noise.

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SIVARANJANI.V.
M.E-Communication Systems, Dhanalakshmi Srinivasan Engineering College, Perambalur.

SURUTHI.S
Assistant professer, M.E-Communication Systems, Dhanalakshmi Srinivasan Engineering College, Perambalur.