A Review of Hyperspectral Remote sensing for Object Identification

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Abstract

Hyperspectral Imaging(HSI) is well suited for identifying the objects and materials in the scene with spectral values since its high spatial and spectral resolution data gives more accurate and detailed description of the object.Targeting ships in HSI is a great challenging task in a cluttered background (e.g.clouds ,plumes,waves,noise,oil spills).This article presents a new approach using both spectral and spatial values for ship detection.The outline of this approach follows three stages : Preprocessing , Information Extraction and Target detection. This paper gives an outlook of various existing methods and techniques for background supression, feature extraction and detecting the target through various stages.

Keywords: Remote sensing Hyperspectral Imaging, Ship detection, Feature Extraction, Target detection.

1. Introduction

Hyperspectral Imaging is attracted towards many applications due to its robustness in handling high dimensional data. A Hyperspectral image deals with hundreds of narrow contiguous band over a wide range of electromagnetic spectrum and generate a unique spectral signature for each pixel in the scene. The spectral resolution can be obtained by the bandwidths of the spectral bands. The objects can be recognized and differentiated by these spectral signatures[1],[9]. Detecting the targets in hyperspectral images gives better results even in low contrast. In HSI the values and wavelenthgs of neighbouring pixels are well correlated. Figure 1 shows about the spectral signature development.

A wide range of satellite imagery are existing to detect ships including oil spills,traffic surveillance and sea pollution monitoring. Ship detection is a great significant research task through remote sensing to monitor the ships entering and leaving the nation. In recent research hyperspectral images are one of the source for ship detection. In this approach both spectral values and spatial values are considered as candidates to detect the ship. Each pixel in the hyperspectral image holds a spectral value. These spectral signatures called end members are used to find the similar and dissimilar pixels which helps to identify the targets[2].

HSI can be represented in different forms. In Spectral representation, all the pixels are represented in the spectral space. Collecting the neighbour pixels which are similar can be grouped in this spectral domain to classify the objects. In spatial representation the neighbouring pixels are grouped spatially due to its high spatial correlation. In spectra-spatial representation spectral processing can be done by considering neighbour pixels into account whereas spatial processing can be done by considering by other bands of image band. [6]

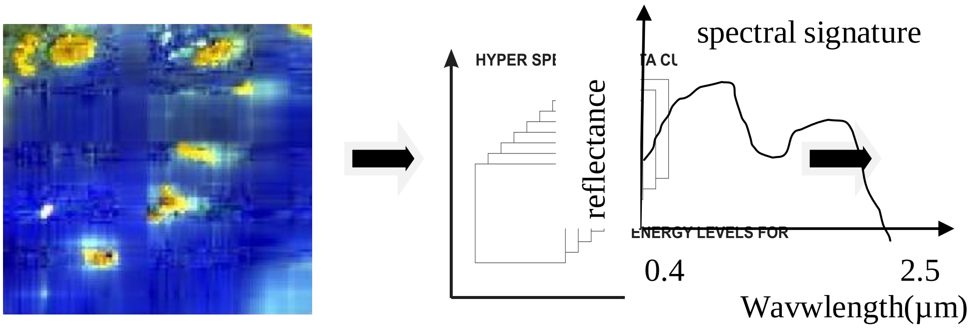

Figure 1: Shows about the spectral signature development.

This approach consists of three stages in target detection: (1) Preprocessing involves denoising and removing disturbances, (2) Information extraction includes background supression and extracting the features , (3) Detecting the target. The following sections of this article gives the brief description about the stages. The sections are organized as follows. Section II describes the detection approach and Section III provides the conclusion of this paper.

2. Detection approach

Detecting ships will become more complex in cluttered environment. Due to noise in the background such as waves, small clouds will leads to detect falsely as ships. There is a need for optimization to decrease the false alarm rate and increase the probability of detection in such environment. Therefore selecting the suitable filters to remove such noise enables the performance improvement in maximizing the detection of ships in preprocessing phase. Next background will be supressed to highlight the target and feature values will be extracted in feature generation phase. Finally the image will be classified as ship or not. The basic a structure of this approach is represented in the following Figure 2.

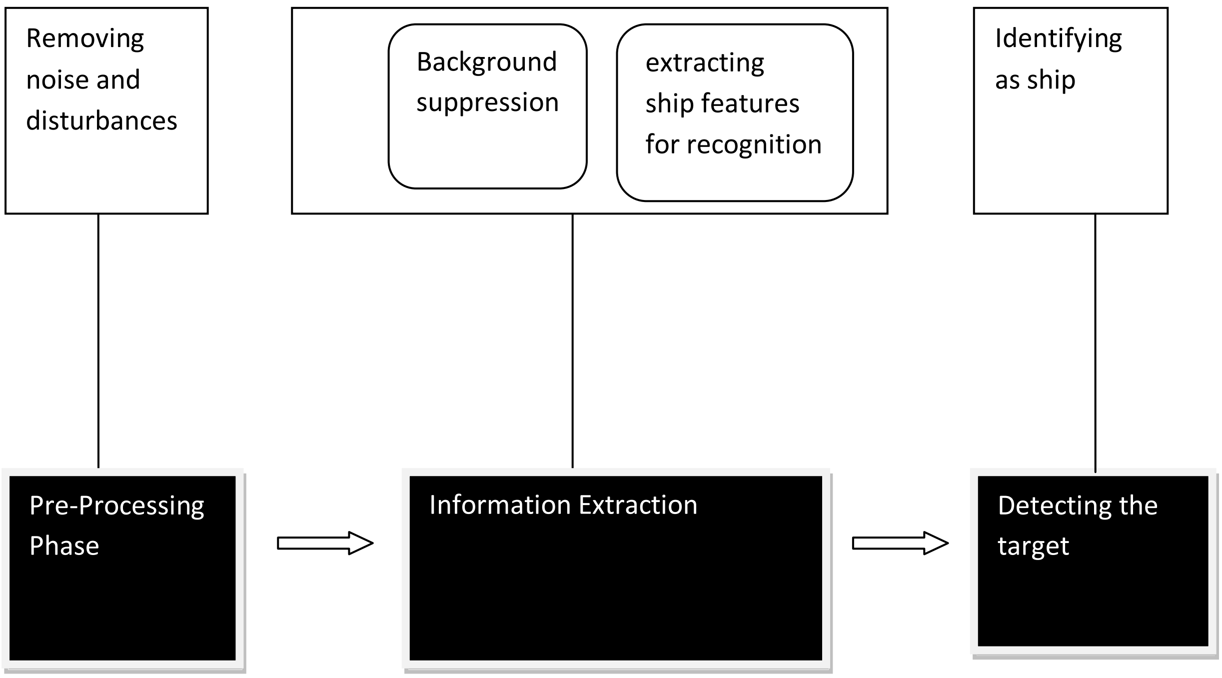

Figure 2 : Flowchart of three stages in ship detection

2.1. Preprocessing

Prior to the other stages in detection numerous corrections are to be made for suitable interpretation of data in this stage [7] . The aim of preprocessing is to denoising the image, smoothing, and image enhancement using binarization, thersholding, resizing, normalization etc. canbe used to get improved version of sampled image. Gaussian distribution removes noise from the image. The spectral signatures collected at different altitudes may vary due to atmospheric correction, sensor effects and other noise factors.The combination of multiple measurements may arise better spectral signatures of the target.

2.2. Information Extraction

The main objective of this stage is separating the target from the background and extracting the target features for identification . Background suppression and extracting the ship features are described below.

2.2.1. Background Supression

Due to high dimensional data, highly spatially variable, extremely clutter environment, seperating the background with accurate models will give better performance. Eliminating these noisy background will steps forward the ship detection accurately and fast. In some applications targets can be detected by gaining prior knowledge about the spectral characteristics of the object[10] . Several methods are availble to seperate the expected target and the background. But none of the method is optimal for all the applications. Choosing the appropriate method may bring efficient results .

Let a hyperspectral image can be represented as (N*L) matrix $X=\{x_1,x_2..x_N\}$ where N represents the total number of spectral bands in the image and L represents the total number of pixels. Several algorithms are briefly discused here. These algorithms provides excellent performance in background suppression and highlighting the targets.

Reed-Xiaoli (RX) is well suitable in hyperspectral images to seperate target and background.Usually the spectral vectors of background takes generously proportioned portion than the spectral vectors of the target in the image. RX algorithm estimates the background then claculates the distance between each pixel and the estimated background. Then the spectral vectors with longer distances will be recognized as targets[12].

Constrained Energy Minimization (CEM) is one of the supervised target algorithms.It extracts some signals of interest while suppressing the least significant signals. It performs well when the targets of interest is known and background is unknown. The background or undesired signatures and the noise are suppressed in terms of energies. CEM can be expressed as

$$\mathbf{CEM(x)} = (\mathbf{w'})^T\mathbf{x} = \left(\frac{K^{-1}d}{d^T K^{-1} d}\right)^T x = \frac{d^T K^{-1} x}{d^T K^{-1} d} \tag{1}$$

The detector operator is appiled on each pixel in the image results in target pixels will be highlighted as brighter pixels while the background pixels are highlighted as the darker ones.[8]

Orthogonal Subspace Projection(OSP) projects the desired target and supresses the undesired background. It can be written as

$$x=a\alpha_{d+}b\alpha_t+n \tag{2}$$

where a is the spectral signature corresponding to the target interest, α_d is unknown endmembers associsated with target spectra, b is endmembers of undesired backround, α_t is unknown endmembers associated with background,n denotes noise. The detector operator is appiled on each pixel in the image results in target pixels will be highlighted as brighter pixels than the background pixels[8].

Target Constrained Interference Minimized Filter(TCIMF)

CEM was extended as target Constrained Interference Minimized Filter (TCIMF). In TCIMF the the signatures of known undesired targets are also included to the detector operation. Along with the target detection, it can also discriminate from each other[11]. It is not suitable for non-linear scenes. KTCIMF works well in non linear subspace which supresses the undesired target spectra in high dimensional space to acheive the better performance.

Kernal based methods

Most of the target detectors are based on first and second order statistics to recognize the targets. Kernel based methods are non linear -based approach. This can be used to transform the data in high dimensionality space by non linear mapping to make the classes lineraly seperable. But the linear algorithms cannot be used with high dimensional data. To make feasibility the inner products of mapped input data are replaced by the kernel functions. The advantage of kernel methods are using kernels in non-linear models gives essential information about the provided data compared to the linear models.By applying the appropriate kernel may find good results in target detection.Some of the existing kernel methods are KOSP, KSMF, KASD, KMSD.

2.2.2. Extracting ship features

It is vital task to extract multiple features of different types to indicate a pixel's information, like spectral, texture, and shape features. Feature extraction is retrieving only the efficient features from the original data for target detection. This helps to reduce the computation time and dimensionality since hyperspectral images are highly dimensional. It is considered as retrieving subspace dimensionality P from the original feature space Q where (P<Q).[13] Feature extraction can be done through linear or non-linear transformations[5]. Numerous methods are avaible for feature extraction. Selecting the poor or ineffective features degrades the detection performance. So a good feature set should be robust and most effective for detection.Few are highlighted here.

Wavelet Based feature extraction

It is a powerful tool which is been used in pattern recogntion,signal processing and image processing.In this method hyperspectral images are implemented with wavelets or wavelet packets transforms(CWT, DWT) to construct the wavelet co-efficients. Then a simple feature procedure is made to choose the appropriate features for detection.

a) Linear Wavelet Feature Extraction

In this method wavelet co-efficients with large amplitudes at small scales may not be selected as features. But the large amplitudes wavelet co-efficients may contain the effective features. For better selection features from both the scales can be combined.

b) **Non-Linear Wavelet Feature Extraction**

By considering N largest wavelet co-efficients as features in x, non linear approximation can be determined.

Principal Component Analysis

In this method maximum of information about the image are selected as components but some special features may be missed[5].

Independent Component Analysis

In this method only the pixels which are not dependent on any other neighbourhood pixels are selected[5].

Linear discriminant Analysis

It projects d-dimensional space to M-1 features with M number ofclasses. The dimension of reduced new feature subset will depend on number of classes. This methods finds the appropriate features for discrmination than other methods.It is applicable only for linear seperable classes[10] .

A good feature selection method choose a better subset from entire of the existing subsets and conserve the physical meaning of the data. When the feature sets increases, the dimensionality of the new subspace will also increases. This leads to complexity in detecting the targets.

3. Detecting the target

Final step of the detction approach is identifying that is target or not. By Implemeting the suitable algorithm based on suitable background subtraction methods, feature selection and spectral /spatial vector generation, the ship detection can become possible with various clutters.The following image was taken from NASA website showing multiple ships and other targets in the oil spilled environment as background by AVIRIS airborne sensor and measurement acquired on May 17, 2010, over the site of the Deepwater Horizon is shown in Figure 3.

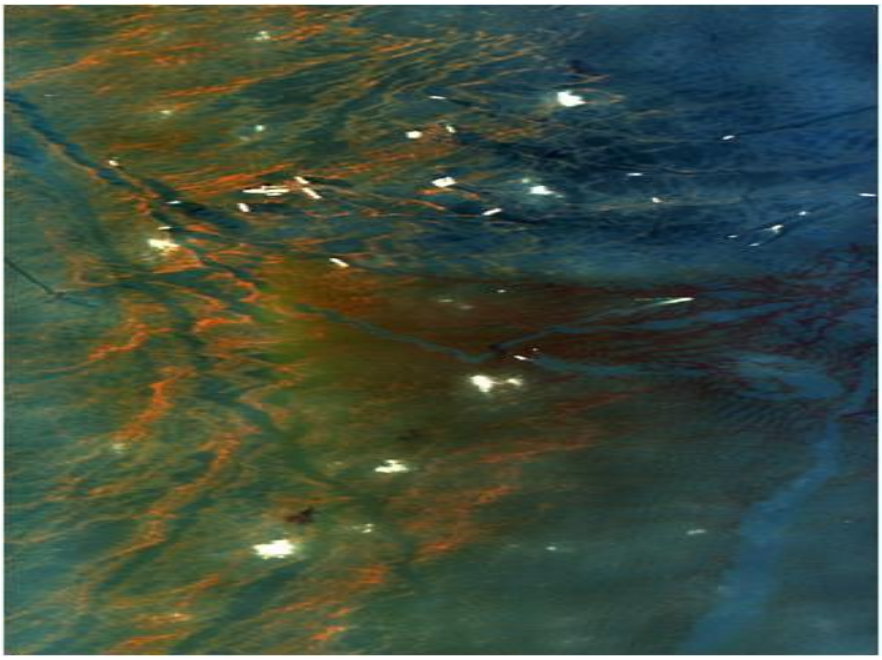

Figure 3: AVIRIS Image of Ships in the oil spill background

In Future work the experimental results can be derived by using the above image.

4. Conclusions

The role of hyperspectral imaging in detection , classification and change detection cannot be exploited. It is fascinated towards many applications due to its highly content data and even works well with low contrast image. This paper overviews about the detection approach in three stages . In each stage the some of the common and popular methods have been glanced . Further studies will be more accurate on all the three phases .

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