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A Review of Shadow Detection and Reconstruction in VHR Images

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Abstract:
Shadows in very high resolution (VHR) images represent serious problems for their full development. This paper faces this complete problem through the proposal of a processing chain, which is based on various advanced image processing and pattern recognition tools. We are using Canny Edge Detection Algorithm. Shadow is one of the most important problems in remotely sensed imagery which affects the accuracy of information extraction and change recognition. In these images, shadow is generally formed by different things, namely, cloud, urban and mountain resources. The shadow correction process consists of two steps: detection and de-shadowing. We are trying to review a range of techniques for both steps, focusing on urban regions (urban shadows), high areas (topographic shadow), cloud shadows and fused shadows. In recent years, thresholding and reconstruction techniques have become significant for shadow detection and de-shadowing, respectively. The purpose of edge detection is to considerably reduce the amount of data in an image, while protecting structural properties for further image processing. This worksheet focuses on a particular one developed by John F. Canny (JFC) in 1986 [14]. Even though it is quite old, it has become one of the standard edge detection techniques and it is still used in research.

Key words: Image re-establishment, image enhancement, shadow detection, shadow reconstruction, very high resolution (VHR) images, urban, forest, canny edge detection

1. Introduction

THE atmosphere, land, and water of the Earth are remarkably complex and do not provide themselves well to being recorded by remote sensing devices that have constraints such as spatial, spectral, secular and radiometric resolution[1][2]. Therefore, Earth′s components can create a range of errors such as geometric errors, atmospheric effects, and topographic errors into the remote sensor data. Such errors can ease quality of remote sensor data recorded and in turn may have an effect on the accuracy of remote sensing research such as land cover mapping [3]. Hence, employing image preprocessing operation is necessary and central step in order to construct corrected image or at least to reduce impacts of these effects. The shadow is one of the most common types of error seen in remotely sensed data. This problem is a main cause of uncertainty and misclassification in extracting land cover information from remote sensing data[6]. In addition, the presence of shadow can also lead to misguidance results if change detection is applied to a ground plane because of changes in shadows, depending on the time and period [7]. So far, different shadow modification methods have been developed in order to produce shadow-less imagery or at least imagery with comfortable impacts due to shadow. Very high resolution (VHR) satellite images opened a new era in the remote sensing field. Because of the increase of spatial resolution, new analysis, classification, and change revealing techniques are required. Indeed, VHR images exhibit resolutions which allow distinguishing very well detailed features of small objects, like little construction structures, trees, vehicles, and roofs [1]. Regrettably, high spatial resolution entails also some downsides like the unwanted presence of shadows, particularly in urban areas where there are larger changes in plane elevation (due to the presence of buildings, bridges, etc.) and as a result longer shadows. Although it is realistic to make use of shadow characteristics to recognize building position and to estimate their height and other useful constraints, usually, shadows are viewed as undesired data that strongly influences images [5]. Shadows may cause a high danger to present false colour tones, to deform the shape of objects, to merge, or to lose objects. They represent an important trouble for both users and retailers of remote sensing images. As a consequence, shadows can affect harmfully in the exploitation of VHR images, influencing detailed mapping, leading to the erroneous classification (e.g., biophysical parameters such as plants, water, or soil indicators), due to the fractional or total loss of information in the image[4][9]. To avoid these drawbacks and, thus, to augment image exploitability, two steps are necessary: 1) shadow detection and 2) shadow reconstruction. An example of the significance of getting shadow-free images are the huge tsunami in 2004 where it was crucial to obtain such images in a very short time in order to take quick and important decisions in rescue missions [10].

1.1. Review Stage

Shadow detection and removal from image related work as below:

- The Mask Pyramid-Based Shadow Removal method [3]: First identify shadowed and shadow-less areas on the same surface in the view using an imposing and edge detection technique. These areas are used to guess the parameters of a vague shadow formation model. A mean and standard deviation difference of pixels is then applied to produce a shadow-free image, while avoiding loss of texture contrast and the introduction of noise. We will try to account for the varying shadow intensity inside the shadowed area by processing it from the interior towards the borders.
- A Complete Processing Chain for Shadow Detection and Reconstruction method [1]:
  The detection and classification tasks are applied by means of the state-of-the-art, we are using various techniques like thresholding, binary imaging, canny edge detection, image fusion etc.
- Detecting and removal method: This starts with a segmentation of the colour image. It is then decided if a segment is a shadow by examination of its neighbouring segment pixels. This is done for all of the colour guides thus leaving a shadow-free colour image. The present method needs neither a calibrated camera nor several images.
- We will then use this edge detected and binary images collectively with the original image to locate shadow edges. We set these shadow edges to zero in an edge representation of the unique image. They can arrive at our required after full colour, shadow free image.

Review Tables

Authors	` Preprocessing Techniques
Paul M. Dare	Thresholding, Region Growing segmentation, Region encoding and filtering Radiometric enhancement Multisource data fusion, Masking
D. Sunil Kumar, M.Gargi	Suport Vector Machine classifier Mask construction, extracting borders smoothening and sharpening functions & methods, morphological operators, segmentation, linear regression
Aliaksei Makarau, Rudolf Richter Rupert Müller and Peter Reinartz	Image Acquisition Illuminant Approximation by Blackbody Radiator
Yael Shor Dani Lischinski	Pyramid-Based Shadow removal
Graham D. Finlayson Steven D. Hordley Mark S. Drew	Segmentation, 3-band color image Technique
Zvi Figov Yoram Tal, Moshe Koppel	RGB technique segmentation, fuzzy c-means (FCM) algorithm
Luca Lorenzi, Farid Melgani Grégoire Mercier	State-of-the-art support vector machine approach linear regression method adaptive morphological filters

Table 1: Existing shadow detection & reconstruction techniques

- Some reviews of the existing shadow detection and reconstruction papers with their result are given in Table 2

Paper Title with Author	Year	Result
Shadow Analysis in High-Resolution Satellite Imagery of Urban Areas Paul M. Dare	2005	Shadow removing process from the image by radio metrically enhancing shadow regions has proved to be a much more difficult challenge to overcome
An Approach In Shadow Detection and Reconstruction of Images. D. Sunil Kumar, M.Gargi	2008	Shadow removing Process changes the original information
Adaptive Shadow Detection Using a Blackbody Radiator Model. Aliaksei Makarau, Rudolf Richter and Peter Reinartz	2011	Fails in vague shadows & road shadows due to higher intensity of the pixels of the roads
A Complete Processing Chain For Shadow Detection and Reconstruction in VHR Images. Luca Lorenzi, Farid Melgani	2012	Complicated techniques used hence difficult and lengthy processing

Table 2: Evaluation of Shadow Detection and Reconstruction methods.

1.2. Previous Research

Shadow Detection & removal:

The paper presented by Paul M. Dare "Shadow Analysis in High-Resolution Satellite Imagery of Urban Areas." has used several techniques for preprocessing and post processing such as thresholding, classification, region growing segmentation, Region encoding and filtering, radiometric enhancement, Multisource data fusion and Masking. Among these methods radiometric enhancement method has proved much more difficult challenge for removing shadows from the VHR imagery.

The paper presented by D. Sunil Kumar & M.Gargi "An Approach in Shadow Detection and Reconstruction of Image" has first took image and segment it into regions and then apply SVM classifier and then it classifies shadow and non shadow regions and then apply feature extraction on shadow regions and then calculate pixel values by distance measure and then apply smoothening &sharpening and apply morphological filters and function & methods which get reconstructed image of shadow. But the drawback is shadow removal process changes the original information of an input image.

The paper presented by Aliaksei Makarau, Rudolf Richter and Peter Reinartz "Adaptive Shadow Detection Using a Blackbody Radiator Model". This paper presents an alternative robust method for shadow detection, which is based on the physical properties of a blackbody radiator. Instead of static methods, this method adaptively calculates the parameters for a particular scene and allows one to work with many different sensors and images obtained with different illumi-nation conditions.But the paper fails in vague shadows & road shadows due to higher intensity of the pixels of the roads.
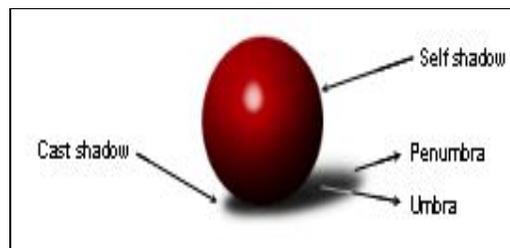
Figure 1: Shodow Types

1.3. Problem Formulation

In satellite VHR images, especially in metropolis, shadows introduced by big tower, trees, bridges, etc may obliterate the information of image. Missing information affects directly on common analysis and processing operation of image, this leads to unproductive classification [1]. In proposed paper, we are using techniques and algorithms to detect these obstacles and to remove it. By this we can get a shadow-free image with the proper information. We focus on cast shadow, which is present in most of images. Cast shadow having property of uniform dark areas, which lead to loss of information in image. This paper works on recovery of image without loss of that information.

In this paper, we are classifying shadow and nonshadow part of image. Canny edge detector algorithm will be used to detect edge of every part of image. For classification of all parts, we will use image imposing technique. Due to these properties, we can find out shadow region and non shadow region. For removal of shadow, we calculate mean and standard deviation of shadow and

nonshadow part of image. Calculate mean difference between shadow and non shadow part. Applying this difference on shadow pixel, we get reconstructed shadow-less image.

1.4. Proposed Methodology
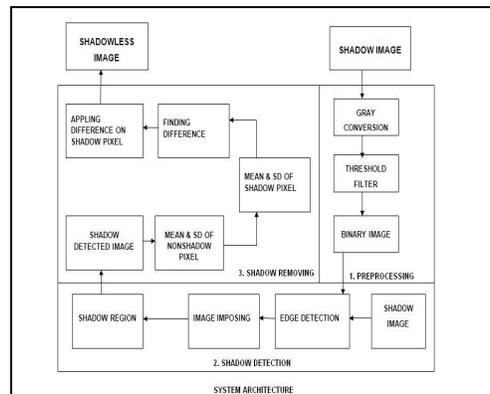
Figure 2: Architecture of the system

Fig. 2 shows a flowchart with the principal step tactic. This image characterized by the existence of shadow area and composed of N bands. This architecture divides into three steps:
- Preprocessing
- Shadow detection and
- Shadows removal.

In first step, we prepare the image for processing by converting color image into gray scale. After this step image contain only intense information. Apply binary classification on grayscale image in order to distinguish shadow and nonshadow areas. Second step is shadow detection, in this step we take original image as an input and apply canny edge detection algorithm to detect all the edges of image. Final result of this algorithm is image having edges. After this, we apply image fusion process. Inputs for image fusion process are, Image having edges, original image and binary converted image. Output of image imposing process is shadow region detected in image. Final step of flow chart is shadow removal. For this step input is shadow region identified image. Calculate mean and standard deviation for shadow as well as nonshadow region of image. Calculate mean difference between shadow and nonshadow region of image. Apply this difference on shadow pixels of image by normalization procedure with the help of standard deviation.

1.5. Preprocessing
Preprocessing of shadow detection and reconstruction is important because it has great impact on the recognition rate. Preprocessing brings the raw data into some specific layout and it gives good results.
Various preprocessing techniques are available from which some are used in previous papers:
Region encoding and filtering, Radiometric enhancement, Mask construction, Binary classification, Image Acquisition etc.
These techniques of image processing have some drawbacks due to which they fail in good, standard results of shadow detection. Hence we are using standard techniques for better and fast results of shadow detection.
The main objectives of preprocessing are:
- Gray Conversion
- Threshold Filter
- Binary Image.

1.6. Shadow Detection
In shadow detection process we are using various algorithms. Canny Edge Detection algorithm is one of the algorithm among them. In this step, original image is converted into blur using Gaussian blur algorithm. This reduces the noise of the image and helps the edge detection algorithm.
The process consists of following steps:
- Edge Detection
- Image Imposing
- Shadow region detection.

After the edge detection process, we impose three images:
- Original image
- Binary image
- Edge detected image.

By this fusion we get exact shadow area of the image.

1.7. Shadow Removing

Shadow removing process works in following phases:

- Shadow Detected Image: This is the image which shows the area of shadow in the image which creates obstacle.
- Mean and SD of Non-shadow Pixels: In this, mean and standard deviation of non-shadow pixels is calculated. This helps in identifying the difference of brightness and intensity of pixels.
- Mean and SD of Shadow Pixels: In this, again the mean and standard deviation of shadow pixels is calculated.
- Finding Difference: Calculate the difference between mean and SD of shadow pixels and non-shadow pixels.
- Applying Difference on Shadow Pixels: In this, we apply the calculated difference on shadow pixels. This is to increase brightness and intensity of the shadow pixels to appear as non-shadow pixels.

2. Conclusion

Through this paper we will try to solve the important problem of shadow images. We are concentrating on solving this problem by not only detecting shadow but also we are removing shadows from image. The techniques used I previous papers has some drawbacks of not removing shadows of the image properly and clearly. In our paper we use binary classification for shadow and no shadow region of image. To get clear borders, we will first apply canny edge detection algorithm and then apply image imposing process on binary image with canny edge detected image and original image. So the output of image imposing will be the classification of shadow and no shadow regions with clear boundary. For reconstruction process, we will calculate mean and standard deviation for shadow and no shadow pixels of image and apply mean difference between shadow and nonshadow pixels to shadow pixels. To improve final result this difference will be applied by using normalization process with the help of standard deviation. By using above methodology we are trying to overcome all the drawbacks of the previous papers.

3. Acknowledgment

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