ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 5, May 2015

Shadow Detection and Reconstruction in Satellite Images using Support Vector Machine and Image In-painting

Hima P. N. [1], Biju V. G. [2]

M. Tech Scholar, Department of CSE, College of Engineering Munnar, Kerala, India[1]

Associate Professor, Department of ECE, College of Engineering Munnar, Kerala, India[2]

ABSTRACT: In this paper an approach for the detection of shadows in satellite images using Support Vector Machine is proposed. The first step is to classify the shadow and non-shadow regions with the help of Support Vector Machine. In order to remove the noise in the classified image median filter is used. The reconstruction of the shadow areas is done by using image in-painting technique. This technique is used to retain the missing parts in an image due to shadows. The performances are evaluated by means of Peak Signal-to-Noise Ratio (PSNR), and Mean Square Error (MSE).

KEYWORDS: Support Vector Machine, Median filter, image in-painting.

I.INTRODUCTION

Satellite images play a key role in the remote sensing field and using these images it is easy to identify each and every object such as shadows, buildings, roads etc. Shadow occurs when objects occlude light from light source. Shadows are represented as undesired information that will strongly affect the images. Due to shadows it is not possible to recognize the original image of a particular object. Shadow in an image reduces the reliability of many computer vision algorithms. However it often degrades the visual quality of images. So Shadow detection and removal is an important task in image processing.

Section II describes the literature survey in short. Section III explains the shadow detection and reconstruction in VHR images (SDRVI). The proposed method is described in Section IV. Section V specifies the details of dataset and parameters. Then Section V draws the results and discussions. Finally Section VI describes the conclusion.

II.LITERATURE SURVEY

There are various methods for shadow detection based on invariant colour features, physical properties of black body radiator etc [1]. Amani Massalabi proposed detecting information under and from shadow in panchromatic Ikonos images of the city of Sherbrooke [2]. Many techniques for shadow detection are developed for video images based on color properties and temporal frame difference. Elena Salvador proposed shadow identification and classification using invariant color models [3]. This method requires luminance and color information for shadow identification. Pooya Sarabandi proposed a method for shadow detection and Radiometric Restoration in Satellite high resolution images [4]. This method detects the boundaries of cast shadow in high resolution satellite images. Also, the shadow detection is performed on the basis of radiometric techniques such as gamma correction, linear-correlation and histogram matching. Kuo-Liang Chung proposed efficient shadow detection of color aerial images based on successive thresholding scheme [5].

III. SHADOW DETECTION AND RECONSTRUCTION IN VHR IMAGES (SDRVI)

High resolution satellite image with shadows were used as the input image. Binary classification was done on the input image in order to distinguish the shadow and non-shadow areas by using support vector machine. From the classified image noise was removed with the help of morphological operations such as opening and closing by reconstruction.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 5, May 2015

After performing the morphological operations a border between the shadow and non-shadow areas were created. A further level of classification was performed in order to localize the shadow and non-shadow region of each class in an image. Then shadow reconstruction was performed on the basis of the linear relationship between shadow and non-shadow class of each object. Finally the border areas were smoothened by using interpolation technique. The block diagram of the SDRVI is shown in Fig. 1.

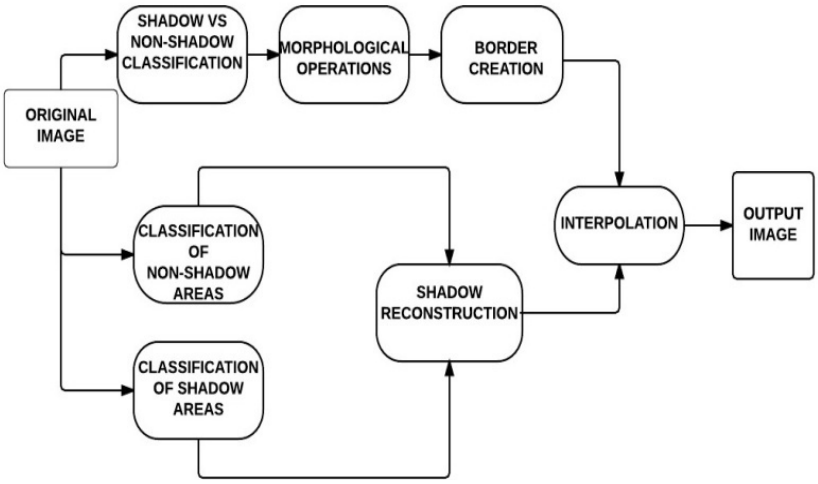

Fig. 1: **Block diagram of shadow detection and reconstruction in VHR images**

The various steps for shadow detection are:

1. **MASK CONSTRUCTION**
   It includes two operations such as Binary Classification and Morphological Filtering.

a) BINARY CLASSIFICATION:

Support vector machines (SVMs) [6] are a set of related supervised learning methods used for classification. So the binary classification procedure was implemented by using Support Vector Machine. In order to perform the classification, different features of the images were needed. So a one-level stationary wavelet transforms i.e, Symlet wavelet was used to extract the features.

b) MORPHOLOGICAL FILTERING

After performing the binary classification, some filtering operations were to be done in order to remove the unwanted pixels or noise in the classified image. So morphological filters were used for removing noise. They were opening by reconstruction and closing by reconstruction [7].

2. **BORDER CREATION**

It was very difficult to classify the shadow and non-shadow areas due to the presence of penumbra. Penumbra is a region where the light source is only partially obscured. For this reason a border between shadow and non-shadow areas were created by using of the morphological operators such as erosion and dilation. So the mask image (c_imgB2) is dilated and eroded. Then, the difference between these dilated and eroded images was computed to form the border image (B[x, y]).

$$B[x,y] = \delta(c\_imgB2[x,y]) - \in (c\_imgB2[x,y]) \qquad (1)$$

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 5, May 2015

3. CLASSIFICATION MAP

The aim of classification map is to distinguish non-shadow and shadow classes. It defines the spectral relationship between the shadow and non-shadow versions of the same object (class), and it is necessary to perform the reconstruction of shadow areas. For this purpose, two multiclass SVMs were used.

4. SHADOW RECONSTRUCTION

The reconstruction of shadow areas were done by using linear regression method. It was possible to reconstruct the shadow areas based on the hypothesis that both shadow and non-shadow classes follow a linear relationship. The mean and standard deviation of shadow and non-shadow class is found out.

$$y = Kx + c \tag{2}$$

$$\mu_{\bar{S}} = K\mu_S + c \tag{3}$$

$$\textstyle\sum_{\bar{S}} = K\sum_S K^T \tag{4}$$

where μ_S and $\mu_{\bar{S}}$ were the mean of shadow and non-shadow class, $\sum_S$ and $\sum_{\bar{S}}$ indicates standard deviation of shadow and non-shadow class. K is the transformation matrix and c is a bias vector. Using factorization method we can find the values of K and c.

$$c = \mu_{\bar{S}} - K\mu_S \tag{5}$$

$$K = U_{\bar{S}} V_S^{-1} \tag{6}$$

where $U_{\bar{S}}$ and V_S are upper and lower triangular matrices related to non-shadow and shadow classes respectively.

5. BORDER RECONSTRUCTION

After the reconstruction of the shadow areas, the processing is not completely finished since thin borders between non-shadow and reconstructed shadow areas still remain with their original aspect, which may be in contrast with the two adjacent areas. In order to smooth such contrast, a linear interpolation technique was applied on the border pixels.

IV.PROPOSED METHOD

Fig: 2 shows the block diagram of shadow detection and reconstruction in satellite images using support vector machine and Image In-painting. The binary classification is done using support vector machine in order to distinguish the shadow and non-shadow regions. And median filtering is applied to the classified image for removing noise. The reconstruction of the shadow area is done by using image in-painting mechanism.

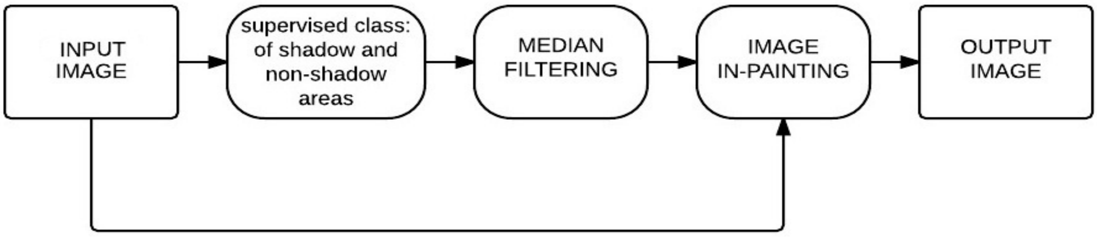

Fig: 2 Block diagram of shadow detection and reconstruction in satellite images using support vector machine and image in-painting.

1. BINARY CLASSIFICATION

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 5, May 2015

The classification of shadow and non-shadow areas are done by using support vector machine. The features are extracted with the help of one level stationary wavelet transform. These features are used for the binary classification of shadow and non-shadow areas. The pixel values of shadow areas are set to 0 and non-shadow areas to 1.

2. MEDIAN FILTERING

Median filtering is very effective for removing salt and pepper noise in an image. It is possible to remove the isolated shadow pixels in the non-shadow area and isolated non-shadow pixels in the shadow area of the classified image. The median filter works by moving through the image pixel by pixel, replacing each value with the median value of neighbouring pixels. The median is calculated by first sorting all the pixel values from the window into numerical order, and then replacing the pixel with the median pixel value. The mask image is obtained after performing the classification and filtering operations.

3. IMAGE IN-PAINTING

In-painting is used for reconstructing the missing portions of an image. The aim is to remove selected portions from the image and fill the removed portions using the background information.

The block diagram of the image in-painting process is shown in Fig 3.

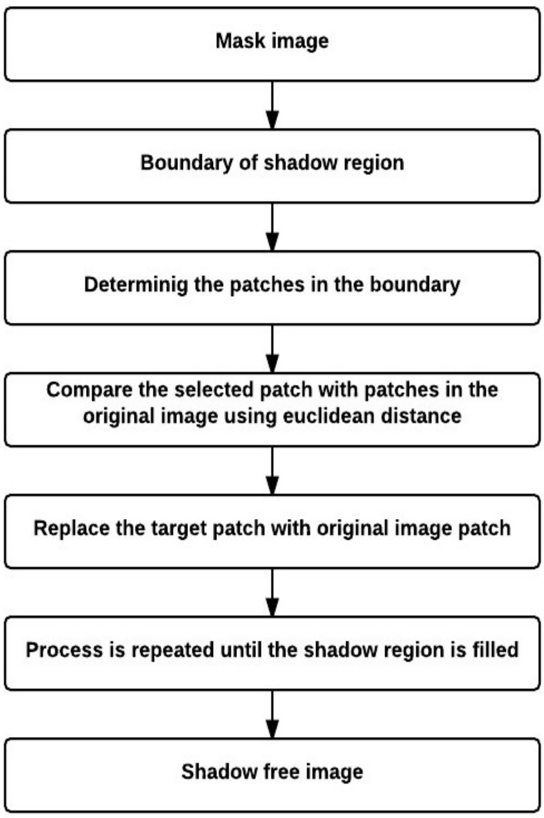

Fig 3: Block diagram of image in-painting process

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 5, May 2015

The steps in In-painting process are:

1. Mask image: After performing binary classification and morphological filtering a mask image is obtained. The mask image in which the region is to be in-painted and original image is given as the input to the in-painting function. The black regions in the mask image are represented as shadows. Using in-painting technique the black regions is to be filled in order to get the shadow reconstructed image.
2. Boundary of shadow region: In this technique, the canny edge detector is used for detecting the boundary of the shadow regions. It is used as an optimal edge detector.
3. Determining the patches in the boundary: To perform the patch wise comparison a patch of 15*15 size is selected for every pixel on the boundary. Each patch is generally called as a template window.
4. Compare the selected patch with patches in the original image: This is done by calculating the Euclidean distance between the selected patch of the shadow mask which is to be in-painted and every patches of the original image. The minimum distance patch of the original image is taken for the replacement of the patch in the shadow area. This process is repeated until all the regions in the target area are filled.
5. In the final stage a shadow free image is obtained.

V.DATASET AND PARAMETERS

A. DATASET

Three different datasets are used:
1. Quick Bird images (coastal region of Boumerdès).
2. Images of centre of the city of Atlanta (USA).
3. Images of peninsula of Jeddah (Saudi Arabia).

B. PARAMETERS USED

The performances are evaluated by means of Mean Square Error (MSE) and Peak Signal-to-Noise Ratio (PSNR) value.

1. Mean Square Error (MSE)

MSE is calculated by averaging the squared intensity of the ground image and the output image pixels as,

$$\text{MSE} = \frac{1}{MN}\sum_{m=0}^{M-1}\sum_{n=0}^{N-1} e(m,n)^2 \qquad (7)$$

where e(m, n) is the difference in error between the ground and the output images. The minimum value of the MSE can be 0 and the maximum value can be ∞.

2. Peak Signal-to-Noise Ratio (PSNR)

Peak Signal-to-noise ratio (PSNR) measures image quality based on the pixel difference between ground and the output image. PSNR is defined as

$$\text{PSNR} = 10\log_{10}\frac{MAX_I^2}{MSE} \qquad (8)$$

Where MAX_I be the maximum possible pixel value of the image. The PSNR value ranges from 0 to 99 [8].

VI. RESULT AND DISCUSSION

The input image which represents the coastal region of Boumerdès is shown in Fig. 4(a).

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 5, May 2015

Fig. 4: (a) Boumerdes image with shadows

The output obtained after performing the binary classification using support vector machine is shown in Fig. 4(b). The black region represents the shadow areas and white region represents the non-shadow areas.

Fig. 4: (b) Binary classification

Median filters are applied on the classified image in order to remove the isolated unwanted pixels. The output obtained after removing the noise is shown in Fig. 4(c).

Fig. 4: (c) Median filtering

Finally, the shadow free image obtained after performing the In-painting technique is shown in Fig. 4(d).

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 5, May 2015

Fig. 4: (d) shadow free image obtained after in-painting technique

The efficiency of the proposed method is compared with SDRVI using three high resolution satellite images and the results are shown in Table 1. By analyzing the table the mean square error (MSE) value is decreased by 0.179% and peak signal-to-noise ratio (PSNR) value is increased by 2.5% as compared to the SDRVI.

Table 1: Comparison between the proposed method and SDRVI

INPUT IMAGE	MSE		PSNR	
	SDRVI	PM	SDRVI	PM
Image 1	0.516	0.135	50.998	56.826
Image 2	0.368	0.251	52.465	54.128
Image 3	0.440	0.400	51.000	51.200

The proposed shadow detection method is compared with SDRVI using boumerdes image. The Fig 6(a) shows the input boumerdes image, Fig 5(b) and Fig 5(c) are the outputs obtained using SDRVI and the proposed method respectively.

(a) (b) (c)

Fig 5: (a) Input Boumerdes image (b) SDRVI (c) proposed method

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 5, May 2015

VII. CONCLUSION

The core of this paper is the reconstruction of VHR images obscured by the presence of shadows. The proposed methodology uses support vector machine for the supervised classification of shadow and non-shadow areas. From the classified image the noise is removed by using median filter. Using the input image and filtered output the image in-painting is performed for the reconstruction purposes. The experimental results shows that the proposed method has higher accuracy with lower error rate as compared to the existing method.

REFERENCES

[1] A. Makarau, R. Richter, R. Müller, and P. Reinartz, "Adaptive shadow detection using a blackbody radiator model," *IEEE Trans. Geosci. Remote Sens.*, vol. 49, no. 6, pp. 2049–2059, Jun. 2011.
[2] A. Massalabi, H. Dong-Chen, G. B. Benie, and E. Beaudry, "Detecting information under and from shadow in panchromatic Ikonos images of the city of Sherbrooke," in *Proc. IGARSS*, vol. 3, pp. 2000–2004, Sep. 2004.
[3] E. Salvador, A. Cavallaro, and T. Ebrahimi, "Shadow identification and classification using invariant color models," in *Proc. IEEE Int. Conf. Acoust., Speech, Signal Process,* vol. 3, pp. 1545–1548, 2001.
[4] P. Sarabandi, F. Yamazaki, M. Matsuoka, and A. Kiremidjian, "Shadow detection and radiometric restoration in satellite high resolution images," in *Proc. IEEE IGARSS*, vol. 6, pp. 3744–3747, Sep. 2004.
[5] K. L. Chung, Y. R. Lin, and Y. H. Huang, "Efficient shadow detection of color aerial images based on successive thresholding scheme," *IEEE Trans. Geosci. Remote Sens.*, vol. 47, no. 2, pp. 671–682, Feb. 2009.
[6] N. Ghoggali and F. Melgani, "Genetic SVM approach to semisupervised multitemporal classification," *IEEE Geosci. Remote Sens. Lett.*, vol. 5, no. 2, pp. 212–216, Apr. 2008.
[7] A. Singh, U. Ghanekar, C. Kumar, and G. Kumar, "An efficient morphological salt-and-pepper noise detector," *Int. J. Adv. Netw. Appl.*, vol. 2, no. 5, pp. 873–875, 2011.
[8] Pooja Kaushik and Yuvraj Sharma, "Comparison Of Different Image Enhancement Techniques Based Upon Psnr & Mse," International Journal of Applied Engineering Research, Vol.7, No.11, ISSN 0973-4562, 2012.

BIOGRAPHY

Hima P. N. received the B. Tech Degree in Computer Science and Engineering from M.G. University in 2012. She is currently pursuing M. Tech Degree in Computer and Information Science at College of Engineering Munnar. Her current area of interest is in image processing.

Biju V. G. received his B. Tech Degree in Electronic Engineering from Cochin University of Science and Technology, Kerala. M. Tech Degree in Electronics and Communication (Optoelectronics and Optical Communication) from University of Kerala.He is an AssociateProfessor in the Department of Electronics and Communication at College of Engineering Munnar, Idukki, Kerala. His areas of interest in research include image processing, Signal Processing, Pattern recognition, and Bioinformatics.