Stochastic Method for De-shadowing and Objects Retrieval from High Resolution Images

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Abstract - Remote sensing is emerging as a strong tool to extract information about the earth resources from the satellite imagery. But this information gets affected by shadow in urban areas. High-resolution satellite imagery offer great possibilities for urban mapping. Unfortunately, shadows cast by buildings in high-density urban envi ronments obscure much of the information in the image leading to potentially corrupted classification results or blunders in interpretation. The principle problem caused by the shadows is either a reduction or total loss information in an image. Reduction of information could potentially lead to the corruption of biophysical parameters derived from pixels values, such as vegetation indices. Total loss of information means that areas of the image cannot be interpreted, and value added products, such as digital terrain models, cannot be created. Keeping this in mind an attempt has been made in this project to study the effect of shadow and its impacts on high-resolution imagery of urban area. Panchromatic image of IKONOS satellite sensor is taken for analysis and its statistical parameters are studied. The image is segmented based on property based and image based techniques according to the spectral and geometric properties of images for detecting shadow regions. This segmentation detection technique is Region growing segmentation which misleads water contained image that is water pixel also identified as shadow pixel. This misleading is corrected with region filtering technique based on the simple logic that water body region have low variance than the shadow region. And from these detected shadow regions, different radiometric enhancement techniques (histogram matching, lightness recovery, gamma correction) are applied to enhance the information under shadow regions and results are discussed.

Keywords – Region growing segmentation Region Filtering ,Gamma Correction, Lightness Recovery, Histogram Matching

I. INTRODUCTION

A. GENERAL

Shadows have played an important role in remote sensing . From the earliest days of aerial photography, the effects of shadowing have been utilized to highlight ground features in applications such as archaeology and aerial reconnaissance. Due to high object density and high proportion of shadows covered areas, it is usually quite difficult to extract information in urban high resolution images.

The high resolution imagery offers great possibilities for urban mapping . Unfortunately ,shadows cast by buildings in high density urban environments obscure much of the information in the image leading to potententially corrupted classification results or blunders in interpretation.

The principal problem caused by the shadows is either a reduction or total loss of information in an image .Reduction of information could potentially lead to the corruption of biophysical parameters derived from pixels values,such as vegetatation indecies.

The effects of shadowing are compounded in regions where there are dramatic in surface elevation , namely in urban areas. The tall buildings are casting shadows that are obscuring many other surface features. Even the smaller buildings are casting shadows that are obscuring many other surface features .Even the smaller buildings are casting shadows that obscuring details on the surrounding areas.

When considering the shadow cast by a typical high –rise building,there are actually two shadows present ; the cast shadow and self shadow.Further shadow can be divided into two that is umbra and penumbra.

B. **Need for the study**

Removal of shadow is essential, especially in high resolution images, because of shadow obscure much of the information in the image, mislead the classification results and blunders in interpretation..Shadows cause serious problems while segmenting and extracting moving objects. Shadows can cause object merging, object shape distortion and even object losses
(due to the shadow cast over another object).

II. STUDY AREA AND DATA DESCRIPTION

C. Location of study area

The areas chosen for this study is of Chennai city in the Chennai district of Tamil Nadu and in the scale of latitude and longitude are in 13°03’45.6’’N and 80°15’54.22’’E.The second areas chosen for this study is of Badshapur city in the state of Hariyana
and in the scale of latitude and longitude are in 28°24’51.79’’ N,77°03’55.78’’ E .

A. *Data used*

- CARTOSAT-2 image of Badshapur,Hariyana.
- IKONOS Panchromatic image of Chennai city, Tamil Nadu.

B. *Software used*

- MATLAB 9a
- ENVI 4.7 EX

III. METHODOLOGY

A. GENERAL

The methodology developed and testeddetecting and removing the shadows from high resolution imagery.Methodlogy involves the following steps

1) Shadow detection
   i)Property based method
      a)Spectral Property
      b)Geometry property
   ii)Image based method
      a) Region Growing segmentation
      b) Region Filtering
2) Shadow Removal
   i)Lightness recovery
   ii)Gamma correction
   iii)Histogram matching

1 Shadow Detection

Shadow are integral parts of natural scene and one of the elements contributing to naturalness of synthetic scenes.In many image analysis and interpretation applications,shadows interfere with fundamental task such as object extraction and description.

A.Shadow segmentation

Segmentation is simply process in which is split into contiguous spatial array of discrete regions .Unlike with classifications , in segmentation pixels are assigned to regions based on their spatial and spectral distance from those regions to which they could potentially be assigned. The following are different methods for segmentation of shadows

1.Model based method
2.Property based method
3.Image based method

Model based methods that relay on models representing the a priory knowledge of the geometry of the scene, the objects, and the illumination.

B. Property based method

Property based method that identify shadows by using features such as geometry ,brightness or color of shadows .It contains two techniques Spectral property and Geometric property .

i)Spectral property

- For a point in shadow the measurements are
  Giving a color vector
  $C_i(x,y)_{shadow} = (R_{shadow}, G_{shadow}, B_{shadow})$,
  It follows that each of the three RGB color components, if positive and not zero,
  decrease when passing from a lit region to a shadowed one, that is
  Rshadow<Rlit;
  Gshadow<Glit;
  Bshadow<Blit:
- Normalization for iC_1 C_2 ,nC_3 *in*variant color features are defined as follows
  C_1 (x,y)=arctan$\left(\frac{R(x,y)}{max(G(x,y),B(x,y))}\right)$
  C_2 (x,y)=arctan$\left(\frac{G(x,y)}{max(R(x,y),B(x,y))}\right)$
  C_3 (x,y)=arctan$\left(\frac{B(x,y)}{max(R(x,y),G(x,y))}\right)$

ii)Geometric Property

- Solar elevation angle can be calculated by
  $\sin\theta_s = \cosh\cos\delta + \sin\delta\sin\varphi$
  Where θ_s , is the solar elevation angle h is the hour angle, in the local side real time, δ is the current sun inclination, φ is the local latitude
- Azimuth angle approximated by
- $\cos\phi_s = \frac{\cosh\cos\delta\sin\phi - \sin\delta\cos}{\cos\theta_s}\phi$
- $\cos\phi_s = \frac{\sin\theta_s\sin\phi - \sin\delta}{\cos\theta_s\cos\phi}$
  Where θ_s is the solar elevation angle,h is the hour angle of the present time,δ is the current sun inclination,ϕ is the local latitude
  Width of the penumbra calculated by w = H $\left[\frac{1}{\tan\left[e-\frac{E}{2}\right]} - \frac{1}{\tan\left[e+\frac{E}{2}\right]}\right]$

We assumed $\sin\theta_s$ **as e and** $\cos\phi_s$ **as E**

C. Image based method

Image based method approach makes use of certain image shadow properties such as color ,shadow structure (umbra and penumbra hypotheses),boundaries ,etc ,without any assumption about the scene structure.They are two methods involved to detect the shadows .

i)Region growing segmentation

Region growing segmentation is a method of shadow detection in high resolution satellite images due to spectral content of the images. Segmentation is simply the process in which an image is split into a contiguous spatial array of discrete regions. Unlike withclassification, in region growing segmentation pixels are assigned to regions based on their spatial and spectral distance from those regions to which they could potentially be assigned.

(a) $\cup_{i=1}^{n} R_i = R$

Means that the segmentation must be complete; that is, every pixel must be in a region.

(*b*)$R_{ib}$is a connected region, I = 1, 2, ...,n

$P(R_{ib})$ is a logical predict defined over the points in set $P(A_{rk})$ and ∅is the null set. Requires that points in a region must be connected in some predefined sense.

(c) $R_i \cap R_j$=∅ for all i = 1,2,…n

Indicates that the regions must be disjoint.

(*d*)$P(R_{ib})$ = *TRUE* for *I* = 1,2,...,*n*.

Deals with the properties that must be satisfied by the pixels in a segmented region. For example $P(R_{ib})$ = TRUE if all pixels in R_{ib} have the same gray level.

(e)$P(R_{ib})$ = *TRUE* for *I* = 1,2,...,*n*.

Indicates that region R_{ib} and R_{aj} are different in the sense of predicate *P*.

ii)**Region Filtering method**

Another method is region filtering method to test the showed resample of shadow is essential in order to get only shadow pixels without misinterpretation pixels that are water as shadow pixel. This corrected by region filtering technique.

cov(x1,x2)=$\in(\boldsymbol{x1}-\boldsymbol{\mu1})(\boldsymbol{x2}-\boldsymbol{\mu1})$,where ∈, **cov(x1,x2)** is the mathematical expectation and covariance. $\boldsymbol{\mu1}, \boldsymbol{\mu1}$ are mean values of matrices. ∈ is the expectation value **μi=∈xi**

2.Shadow Removal

In order to get the information under shadow regions , three radiometric enhancement techniques are presented below for removing shadows from high resolution imagery. Radiometric Enhancement involved three methods to carry out this task: an algebraic grayscale transformation, histogram equalization, and a mean and variance transformation surrounding the shadow.

i) Histogram matching
ii) Lightness recovery
iii) Gamma correction

i)**Histogram matching**

Histogram matching matches the histogram of image or region of interest (ROI) to another to make the brightness distribution of the two images or ROIs as close as possible. With this function, the histogram of the region of interest (shadow) where the function is started and changed to match another ROI (buffer Zone of shadow) of histogram. The histograms of neighboring regions are adjusted to match each other in order to minimize the radiometric differences across the boundary of shadow regions . The following steps involved

- When you supply a desired histogram hgram, histeq chooses the grayscale transformation *T* to minimize
  $\boldsymbol{C_1}$(**T(k)**-$\boldsymbol{C_0}$**(k)**)
- where c_0 is the cumulative histogram of A,
  $\boldsymbol{c_1}$ is the cumulative sum of hgram for all intensities ***k***.
- This minimization is subject to the constraints that *T* must be monotonic and $\boldsymbol{c_1(T(a))}$ cannot overshoot $\boldsymbol{c_0(a)}$ by more than half the distance between the histogram counts at ***a***.
- **Histeq** uses this transformation to map the gray levels in X (or the color map) to their new values.
  b=T(a)
- histeq creates a flat **hgram,** (ie)**hgram = ones(1,n)*prod(size(A))/n;**

ii)Gamma Correction

After shadow detection , the each shadow regions are considered as discrete matrices within the matrix and having its own statistical parameters. Here mean value of the matrices are taken as the key factor to find out the ‘ Gamma correction’. Due to the absence of direct illumination, the actual DN values are suppressed and thus by its statistical values .

Outpixel =2047*(inpixel/2047)$^{1/\gamma}$

Where Outpixel=output pixel value
Inpixel=input pixel value
The gamma value has to be determined for each image

γ=Sy/Sx*(x-x_m)+(y-y_m)

Where
X =input pixel value
Y=output pixel value
x_m =Average of input density
y_m=Average of output density
Sx- sum of input pixel value
Sy-sum of output pixel value

iii) **Lightness Recovery**

Threshold derivatives are used to remove the effect of illumination. Sensor response is a multiplication of light and surface. The gradient differential operator takes differences of adjacent image pixels .Assuming locally constant illumination ,the differences between log color responses removes the effect of the illumination.

Calls for direct calculation of lit pixels from shadowed pixels

$I(x,\boldsymbol{\lambda}) = \boldsymbol{L}(x,\boldsymbol{\lambda}) * R(x,\boldsymbol{\lambda})$

Split illumination

$\boldsymbol{L}(x,\boldsymbol{\lambda}) = L^{d}(x,\boldsymbol{\lambda}) + L^{a}(x,\boldsymbol{\lambda})$

For lit regions

$L^{ht}(x,\boldsymbol{\lambda}) = L^{d}(x,\boldsymbol{\lambda}) * R(x,\boldsymbol{\lambda}) + L^{a}(x,\boldsymbol{\lambda}) * \mathbf{R(x,y)}$

Shadowed regions

$I^{shadow}(x,\boldsymbol{\lambda}) = \mathbf{a(x)} * L^{a}(x,\boldsymbol{\lambda}) * \mathbf{R}(\mathbf{x},\mathbf{y})$

Combining equations

$I^{ht}(x,\boldsymbol{\lambda}) = L^{d}(x,\boldsymbol{\lambda}) * R(x,\boldsymbol{\lambda}) + \frac{\mathbf{1}}{\boldsymbol{a}(\boldsymbol{x})} * I^{shadow}(x,\boldsymbol{\lambda})$

Transformation to images with pixels

$I_k^{ht}(p) = \propto_k(\mathrm{p}) + \gamma(p) * I_k^{shadow}(p), k \in \{R.G,B\}$

$$\gamma = \frac{\sigma(L)}{\sigma(S)}$$

$\propto_k = \mu_k(L) - \gamma\mu_k(S), k \in \{R,G,B\}$

IV.RESULTS AND DISCUSSIONS

1. SHADOW DETECTION RESULTS

IKONOS and Cartosat2 Panchromatic image are taken for analysis and its statistical parameters are studied is shown in Figures 1.and 2.

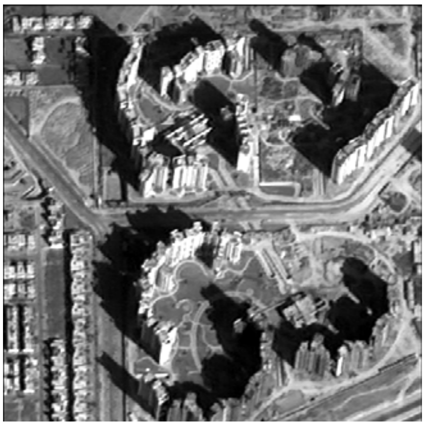


Fig 1 Cartosat2 image showing building and their shadows

Fig 2. IKONOS image showing building and their shadows with water

A. Spectral property Results

Fig 1 shows Cartosat2 image showing building and their shadows and shadow detected image seen in Fig 3. on the basis of brightness or color of shadows.

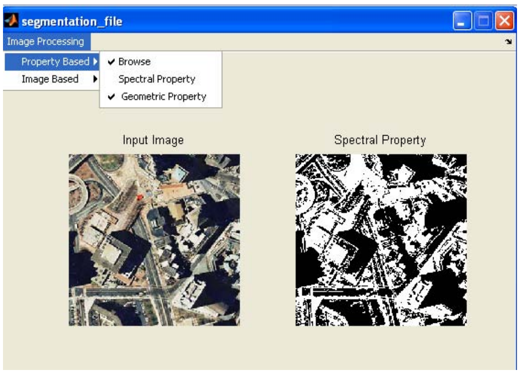


Fig 5.8 Shadow detection based on Spectral Property

B. **Geometric property Results**

Using sun elvation angle is 45 degree and azimuth angle is 86 degree of IKONOS image ,the shadow are detected seen in fig 5.10

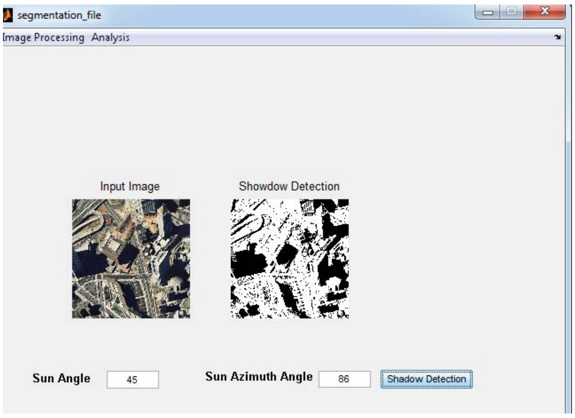


Fig 5.10 Shadow detection based on geometric Property

C.Region Growing Segmentation Results

Shadow are detected from IKONOS image by using region growing segmentation with isinterpretation of water as shadow pixel as shown fig 4.

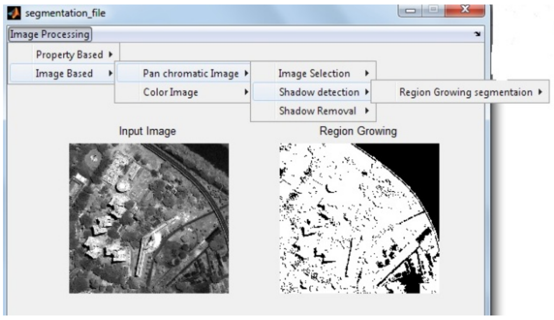


Fig 5.3 Subset of shadow detected image with misinterpretation of water as shadow pixel.

Fig 5.3 shows shadow detected image with misinterpretation of water as shadow pixel.

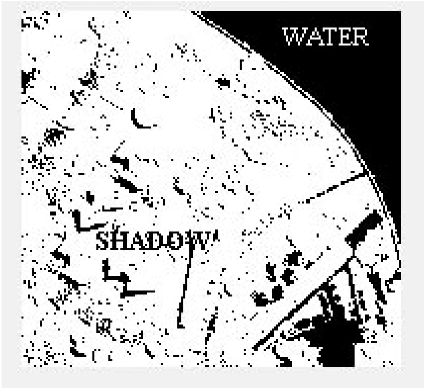


Fig 5.4 Image interpretation of water as shadow pixel

C. **Region Filtering Results**

Here variance value of shadow regions having the minimum variance value was truncated that is water segments are eliminated. Thus the misinterpretation of water as shadow is removed by using the “region filtering” technique.

Fig 5.5 Resampling of shadow regions using variance

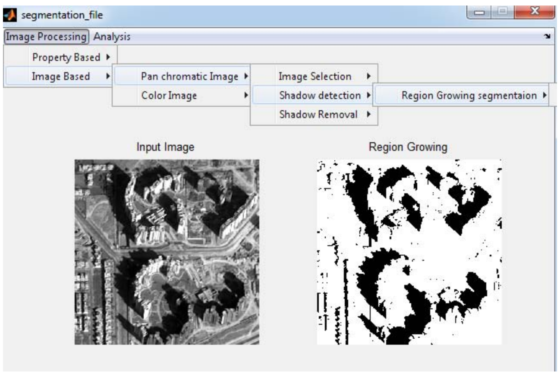
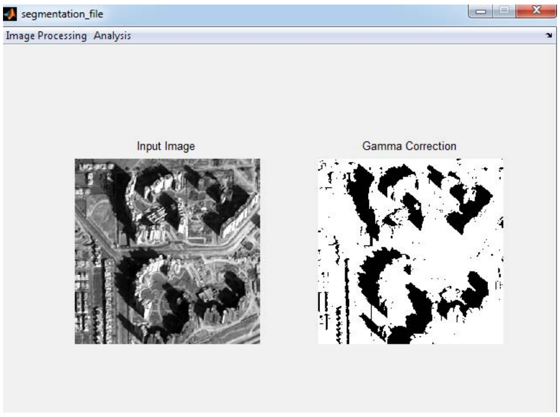


Fig 5.6 Subset of shadow detected image of Cartosat2

Fig 5.1 shows Cartosat2 image showing building and their shadows and shadow detected image seen in Fig 5.6.



The fig 5.11(a) shown the subset of panchromatic CARTOSAT 2 image before histogram matching having very dark shadow contains no information under the shadow region the fig 5.11 (b) shows output image after the histogram matching contains the information under the shadow region

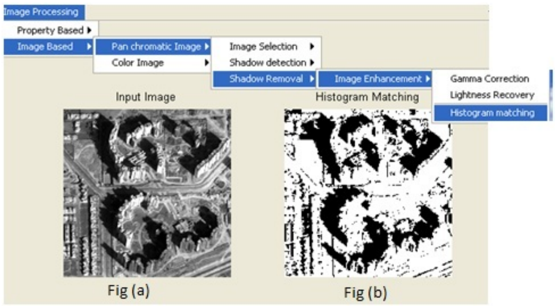


Fig 5.11 subset of panchromatic CARTOSAT 2 image after the histogram matching

D .Gamma Correction results

The fig 5.12 shown the subset of panchromatic CARTOSAT 2 image as input image before gamma correction having very dark shadow contains no information under the shadow region and output image after the gamma correction contains the information under the shadow region .

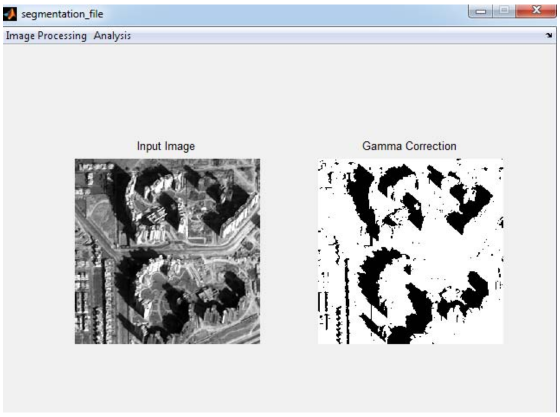


Fig 5.12 shadow removal by ‘gamma correction’

E.Lightness recovery Results

The fig 5.11 shown the subset of panchromatic CARTOSAT 2 image as input image before lightness recovery having very dark shadow contained so there was no information under the shadow region and output image after the lightness recovery obtained more information under the shadow region

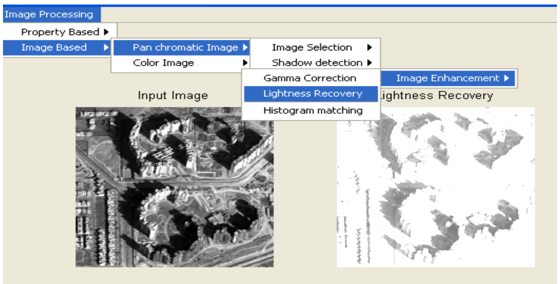


Fig 5.13 shadow removal by 'lightness recovery'

F. Menu design using GUI

The main menu of image processing consists of property based and image based techniques which are implemented using both panchromatic and color images.

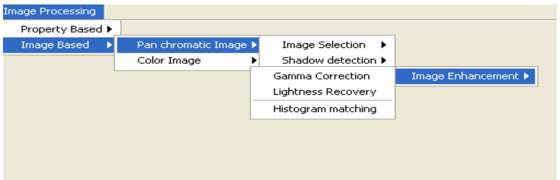


Fig 5.14. Main Menu Design

G.Validation of results

From the application of shadow detection , the best results are obtained from region growing segmentation in the image based technique using spectral property and property based technique using geometric parameters such as sun angle, sun azimuth angle . From the application of the shadow elimination method ,best result is obtained by using lightness recovery compared to the histogram matching and gamma correction. So image based technique and property based technique are best techniques for the shadow detection. The image is taken from the internet from the web site is called Google earth for the same subset of Cartosat-2 image with shadows. By comparing subset image with output of lightness recovery, it came to known that the shadow region in the tested subset image may be car park and the same is verified.

Fig 5.15. Subset image from Google earth with 3D

The image is taken from the internet from the web site is called Google earth for the same subset of Cartosat-2 image with shadows. By comparing subset image with output of the lightness recovery , it came to known that the shadow region in the tested subset image may be the Car park and the same is verified.

The image is taken from the internet from the web site is called Google earth for the same subset of IKONOS image with shadows and water areas.

F.Shadow analysis

After shadow elimination using three techniques such as gamma ,lightness and histogram ,information are obtained from output that are analyzed as shown in figure

V.CONCLUSION

Shadows in the original image are first identified by the suggested method using panchromatic image of resolution 1 meter. Shadows are detected using different techniques such as model based ,property based and image based .In the research ,Region growing segmentation is best method to detect shadows. So image based technique approach is best method .In the research ,Property based techniques that identify shadows by using features such as geometry, brightness or color of shadows. Sun angle and sun azimuth angle parameters used in shadow detection techniques. The shadow removal is done by using histogram techniques ,lightness recovery and gamma correction where applied to restore the brightness of shadow regions of the image . In the research Gamma correction factor is arrived based on the regions mean only. The improved and accurate correction factor can be arrived by using the other statistical parameters and region's specific characteristic thus leads to the results . In the lightness recovery algorithm, the shadow regions are enhanced, information are retrieved from the shadows .The test carried out over Google earth image images with neighborhood weights may lead to better shadow detection and elimination because with RGB and Grayscale value we may get improved results. The present shadow detection and elimination methods do not require a DSM or DEM but Sensor parameters are needed for geometry based techniques.

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