Removal of Cirrus Cloud Effects over the Coastal Regions for Remote Sensing

Lakshmi Priya V
PG Scholar, Department of ECE
Kumaraguru College of Technology
Coimbatore-641049. Tamilnadu.

A Vasuki, Ph.D
Professor, Department of ECE
Kumaraguru College of Technology
Coimbatore-641049. Tamilnadu.

ABSTRACT
The cirrus clouds are a sort of transparent clouds that are barely visible in many satellite images. These clouds form a reflection effect in the images which hide the crucial information in remote sensing. Thus the removal of cirrus effect is essential to have an effective remote sensing over coastal regions and the following proposed algorithms proved to be cirrus-free images. The techniques used here is Generic and Otsu algorithms which is based on segmentation and thresholding respectively. The empirical technique is described,and the sample analysed results are presented. The algorithms proposed here are applicable to cirrus corrections over clear water surfaces for other hyperspectral imaging instruments.

Keywords
Cirrus clouds, Remote sensing, ocean color, Genetic algorithm.

1. INTRODUCTION
During the process of remote sensing, many factors such as reflection, scattering, environmental changes, relative motion of camera, sensor characteristics and so on cause disturbance in images. In this paper, the concentrated factor is reflection that is caused by the cirrus clouds. Cirrus clouds are the genus of atmospheric clouds generally characterized by thin,wispy strands and they appear in white or grey in color.Cirrus clouds consists of ice particles and these clouds are formed when watervapour undergoes deposition process at altitudes above 5,000m in temperate regions and above 6,100m in tropical regions.Thin cirrus clouds are considered as aerosols in atmospheric correction algorithm for ocean color applications [5].Some cirrus clouds are composed with ammonia or methane ice rather than water ice. These cirrus clouds hides the remote sensing information like underwater and land surface features in the captured satellite image by its reflection. Thus, the cirrus clouds are to be removed necessarily to have an effective remote sensing over coastal regions.

The challenges we face through the watery transparent clouds are as follows: The ocean surface when imaged from an aircraft or from space, it is viewed through an atmosphere which is substantially brighter than the underlying ocean because of atmospherically scattered sunlight. The effects of the atmospheric signal and atmospheric absorption lines reaches the ocean surface which creates Sea surface reflectance, Bottom reflectance and in water scattering which leads to formation of transparent clouds to contaminate the images. The Hyperspectral Imager for the Coastal Ocean(HICO) instrument onboarding the International Space Station (ISS) [2],[3] provides the spectral imaging data of the coastal regions for remote sensing which contains the cirrus effects that are covered by thin cirrus clouds. The areas contaminated by the cirrus scattering effects from the hyperspectral imaging data is retrieved based on two facts [1] . The water leaving reflectances are zero over clear ocean waters and the thin cirrus reflectances in the specific spectral region is nearly constant[4],[5]. However in this paper, two different algorithms such as Genetic segmentation algorithm and Otsu thresholding approach has been proposed.

In section 2 we present the Genetic segmentation algorithm for cirrus correction. In section 3, we present the next algorithm Otsu thresholding method for removal cirrus effects. In section 4, simulation results are discussed for both the proposed algorithms. Section 5 concludes the paper.

1.1 Related Work
Surface reflection method uses HICO images along the spectral region of 0.4 to 1 μm and it eliminates the reflection in step by step manner. The HICO imager instrument which is onboarding the International Space Station (ISS) is used for the spectral image datas. The HICO is the first spaceborne hyperspectral sensor designed specifically for the coastal ocean and estuarial, riverine,or other shallow – water areas. The HICO generates images of over 400-900 nm spectral range, with a ground sample distance of approx 90m and with high SNR. Its cross-track and along-track fields of view are 42km and 192km, respectively . The HICO is an innovative prototype sensor that builds on extensive experience with airborne and space sensors.

Atmosphere removal method uses airborne spectrometers to collect the data from their spectral location. The majority of users of imaging spectrometer data are interested in studying the properties of surface . The atmospheric absorption and the effects of scattering must be removed from imaging data of spectrometer , so that the surface reflectance spectra can be derived. The Malkmus narrow band model is used for the Imaging spectrometers to obtain spectral resolutions finer than 10 nm.The method is not successful for the band model not suite with the data collected by spectrometers. Thus we came out with the thresholding and segmentation model to save the datas from the cirrus contamination.

2. GENETIC SEGMENTATION ALGORITHM
In this subsection, the genetic segmentation algorithm is reviewed which simulates the reflection effect caused by the transparent icy cirrus clouds. Genetic algorithm is a search techn3ique used in computing to find true or approximate

solutions to optimization and search problems [6]. Genetic algorithms are a particular class of evolutionary algorithms that uses techniques such as selection, inheritance ,crossover (also called Recombination) and mutation. These are implemented as a computer simulation in which a population of abstract representations(called Chromosome or Genotype or Genome) [8] of candidate solutions to an optimization problem evolves toward better solution.

Segmentation involves separating an image into regions corresponding to objects . Segmentation involves in segmenting regions by identifying common properties, While contours are identified based on its differences between regions.This model supports the cirrus correction over satellite images.

A genetic algorithm is defined by considering five essential data:

1. *Genotype:* The image segmentation result is considered as an individual described by the class of each pixel,

2. *Initial population:* A particular set of individuals is characterized by their genotypes. It is composed of the segmentation results to combine,

3. *Fitness function:* This is the function which enables us to quantify the fitness of an individual to the environment by considering its genotype. The evaluation criteria described in the previous sections can be used as a fitness function in the unsupervised case or in and in the semi-supervised cases,

4. *Operators on genotypes*: They are the ones which define the alterations on genotypes in order to make the population evolve during generations. Three types of operators are used:

• *Individual mutation*: The genes of an Individual are modified in order to be better adapted to the environment. We use the non-uniform mutation process which randomly selects one chromosome xi, and sets it as equal to a non-uniform random number:

$$x' = \begin{cases} x1 + (b1 - x1)\, f(G) & if \;\; r1 < 0.5 \\ x1 - (x1 + a1)\, f(G) & if \;\; r1 \geq 0.5 \end{cases} \quad \text{-- (1)}$$

where

$$f(G) = (r_2\,(1 - \frac{G}{Gmax}))^b$$

r_1,r2 : Numbers in the interval [0, 1]

ai,b_i: lower and upper bound of chromosome x_i

G : The current generation

Gmax : The maximum number of generations

b : A shape parameter

• Selection of an individual: Individuals that are not adapted to the environment do not survive to the next generation. We used the normalized geometric ranking selection method which defines a probability Pi for each individual i to be selected as following

$$Pi = \frac{q\,(1-q)r - 1}{1-(1-q)n} \quad \text{--(2)}$$

where

q : The probability of selecting the best individual

r : The rank of individual, where 1 is the best

n : The size of the population

• Crossing-over: The reproduction can be done by combining two individual's genes. We use the arithmetic crossover which produces two complementary linear combinations of the parents:

$$X' = aX + (1 - a)Y \quad \text{--(3)}$$

$$Y' = (1 - a)X + aY$$

where

X,Y : Genotype of parents

a : A number in the interval [0, 1]

X′,Y′: Genotype of the linear combinations of the parents

5. Stopping criterion : This criterion which allows to stop the evolution of the population. We can consider the stability of the standard deviation of the evaluation criterion of the population or set a maximal number of iterations (we used the second one with the number of iterations equals to 1000).

Given these five informations, the execution of the genetic algorithm is carried out in four steps:

1. Definition of the initial population (Segmentation results) and the Computation of the fitness function

(Evaluation criterion) of each individual,

2. Mutation and Crossing-over of the individuals,

3. Selection of the individuals,

4. Evaluation of the individuals in population,

5. If stopping criterion is not satisfied, back to step 2.

6. Optimize the new set of values to construct the cirrus corrected data.

The algorithm starts with the randomly generated individuals and happens in generation.In each generation , the fitness of every individual in the population is calculated,multiple individuals are selected from the current population (based on their fitness), and modified (recombined and possibly mutated) to form new population.

The new population is then used in next iteration of the algorithm [9]. The algorithm terminates when either a maximum number of generations has been produced,or a satisfactory level of fitness has been reached for the population.

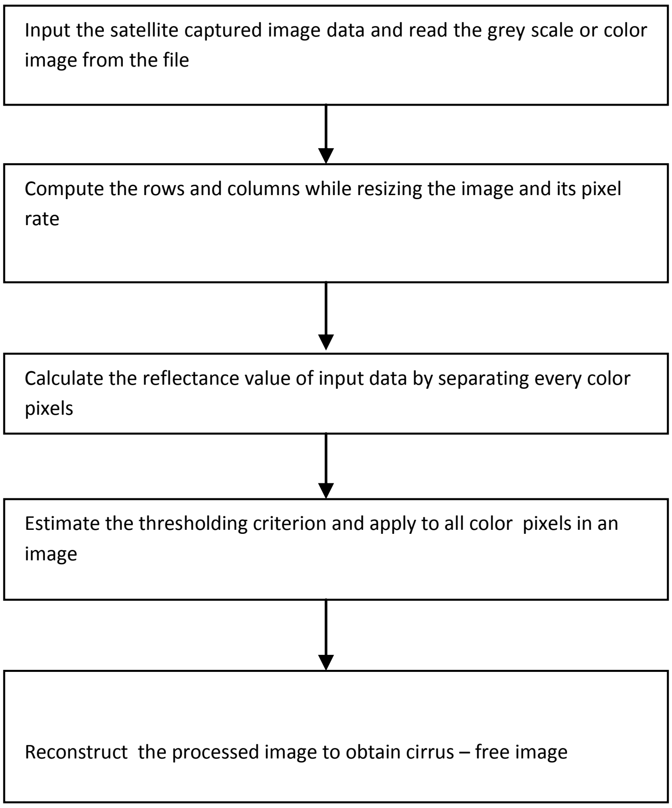
3. OTSU THRESHOLDING ALGORITHM

Otsu Thresholding method involves iterating through all possible threshold levels and calculating the measure of spread for the pixel values each side of the threshold i.e., the pixel that fall either on the foreground or the background. The aim is to find out the threshold value where the sum of the foreground and background spreads is at its minimum. Otsu,is one of the many binarization algorithm.

In the gray scale, it scales from 0 to 255.i.e..256 levels. In binary image , it has only 2 levels which is black and white. Directly converting color images (like RGB) to binary is not that easy , because we have to handle every color channel within the image separately. And therefore converting to binary is done using a certain threshold, eg: all pixels with gray greater than 125 will become white while the others black.

There are several thresholding algorithms out there, the most common is' Thresholding by Otsu'.

The simplest property that pixels in a region can share is intensity. So, the natural way to segment such region is through the thresholding ,separation of the light and dark regions. Thresholding creates the binary images from the grey level ones by turning all pixels below threshold to zero and all pixels above that threshold to one.

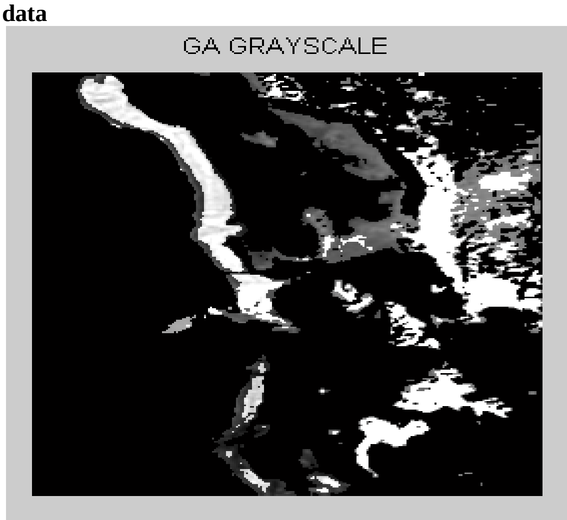


Where, μ_0 = Cosine of solar zenith angle .

The thresholding criterion to all color pixels in an image,

$$[\ S(i,j) >= Th\ (i,j)\ ] \approx Cons \quad --(5)$$

Fig (b) Gray Scale representation of Cirrus removed data



$$[\ S(i,j) < Th\ (i,j)\ ] \approx 0$$

The above algorithm initially get all the input image and resize it based on the application. It computes all rows and columns while separating the primary colors (RGB) from an image. Resizing preserves the image aspect ratio automatically. Compute the threshold value and apply to each color in the matrix separately.The obtained binary image is multiplied with RGB matrix to produce the Gray scale image [10]. Finally, reconstruct the processed image with the input data which purely excludes the cirrus effect by considering it as disturbance [11]. This algorithm gives out a reflection less cirrus free coastal region image .

4. SIMULATION RESULTS

The proposed algorithm is applied on satellite images and their simulation results are presented below. The input image has a sun glint like effect in the centre of the image data. This will hide certain surface and ocean bed properities. The cirrus contaminated image is rectified and shown in gray scale too, which shows the amount of accuracy of the cirrus correction among the satellite data .

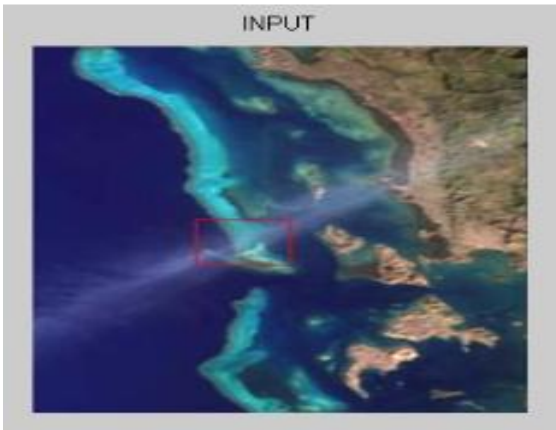
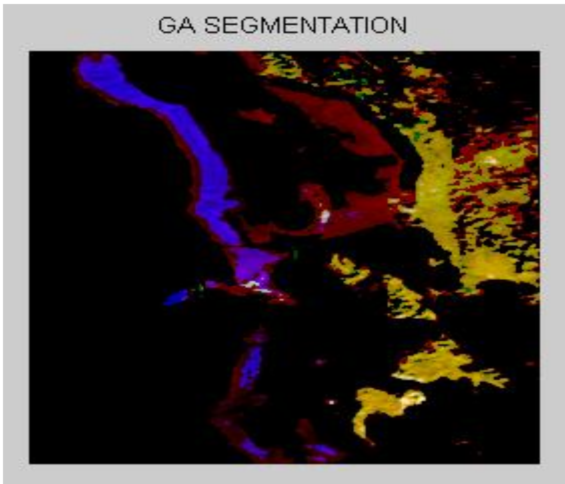


Fig (a) Input Satellite data used for cirrus correction



Fig(c)Cirrus Corrected data by segmentation algorithm

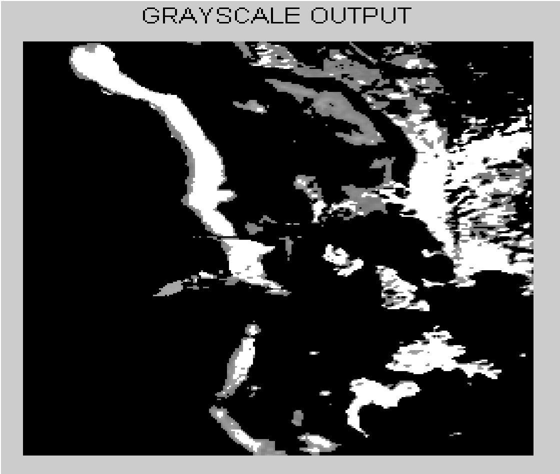


Fig (d) Gray scale output data representation

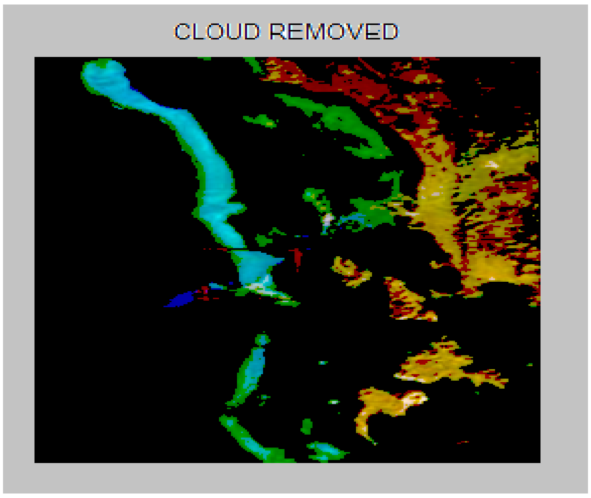


Fig (e)Cirrus removed data through thresholding algorithm

Fig (a) Input satellite coastal image for cirrus removal,.(b) Gray scale output by segmentation method,(c) Cirrus corrected image by Genetic segmentation algorithm, (d) Gray scale output image by Otsu method , (e) Cirrus corrected image by Otsu Thresholding algorithm.

The reflection effect due to cirrus clouds is seen in fig (a) which is highligted in red box. The reflectances due to cirrus clouds is cleared out by following Otsu thresholding algorithm in the fig(c).

The gray scale output images are presented here to understand about the extent of the cirrus correction in the proposed algorithms.

5. CONCLUSION

The Genetic Segmentation and Otsu Thresholding algorithms are implemented for the cirrus removal in satellite images. The cirrus effects were corrected and the results are shown. The technique is applicable for other hyperspectral images in remote sensing. The paper can be extended for cirrus correction of multispectral images and can be worked on thick cirrus clouds.

6. REFERENCES

[1] Bo-Cai Gao,and Rong-Rong Li,"Removal of Thin Cirrus Scattering Effects for Remote Sensing of Ocean Color from the Space",*IEEE Geoscience and Remote Sensing Letters,Vol. 9,No .5,pp. 972-976,Sep 2012.*

[2] R. L. Lucke, M. Corson, N. R. McGlothlin, S. D. Butcher, D. L. Wood, D. R. Korwan, R. R. Li, W. A. Snyder, C. O. Davi, and D. T. Chen, "The Hyperspectral Imager for the coastal ocean region: Instrument description And first images," *Appl. Opt.*, vol. 50, no. 11, pp. 1501–1516, 2011.

[3] M. R. Corson and C. O. Davis, "A new view of coastal oceans from the space station," *EOS*, vol. 92, no. 19, pp. 161–168, 2011.binson, S. Farsiu, nd P. Milanfar, "Optimal registation of aliased images using variable projection with applications to Super- resolution," *Comput. J., vol. 52, no. 1, pp. 31–42, Jan. 2009*

[4] B.-C. Gao *et al.*, "Correction of thin cirrus path radiances in the 0.4–1.0 mm spectral region using the sensitive 1.375 mm cirrus detecting channel," *J. Geophys. Res.*, vol. 103, pp. 32 169–32 176, 1998.

[5] H. R. Gordone and M. Wang, "Retrieval of water leaving radiance and aerosol optical thickness over the ocean with the SeaWiFS: A preliminary algorithm," *Appl. Opt.*, vol. 33, no. 3, pp. 443–452, Jan. 1994.

[6] R.C. Joshi and Shashikala Tapaswi,"Image Similarity :A Genetic Algorithm Based Approach ",World Academy Of Science, Engineering and the Technology, No: 3,2007.

[7] L. Tang, L. F. Tian, B.L. Steward, " Color Image Segmentation with " Genetic Algorithm for In Field based Weed Sensing ".

[8]] Raj Kumar Mohanta and Binapani Sethi " A Review of Genetic Algorithm application for Image Segmentation", Raj Kumar Mohanta et al ,Int .J..Computer Technology & Applications,Vol 3 (2), 720-723.

[9] P. Kanungo, P. K. Nanda and U. C. Samal , "Image Segmentation Using Thresholding and Genetic Algorithm ".

[10] Jun Zhang .M, Jinglu hu "Image Segmentation Based on 2D Otsu Method with Histogram Analysis ",2008 International Conference on Computer Science and Software Engineering.

[11] Nobuyuski Otsu, " Image Binarization Using Otsu Thresholding method ", " a Threshold Selection Method from the Gray Level Histograms", Apr 2009.

[12] S.T.Chabrier,C.Rosenberger,B.Emile,H.Laurent,"Optimization Based Image Segmentation by Genetic Algorithms","EURASIP journal on Video and Image Processing ,2008.