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Review on Haze Removal Methods

Anuj Sharma[1], Vikas Khullar[2], Priya Sachdeva[3]

Department of CSE ,CTIEMT , Jalandhar, Punjab

Abstract - *This paper reviews and correlates various haze removal methods/techniques in remote sensing images. The remote sensing images have their own importance in area of geography, land surveying, military, intelligence and most Earth Science disciplines. The impurities (haze, fog, dust etc.) present into atmosphere downgrade the vision quality of remote sensing images and make them impractical for the above disciplines .The deep distance between visual sensor and scene also may be cause of low perception level. A number of techniques has been proposed by various researchers on remote sensing images in order to remove the haze and fog effect. The main intent of this review paper is to study and compare the distinct techniques of haze removal along with its drawbacks.*

***Key Words*: Haze Removal, Gradient Profile prior, Differential Evolution , Dark Channel Prior, Filtering.**

1. INTRODUCTION

Remote sensing images acquired by multispectral sensors, such as the widely used Landsat Thematic Mapper (TM) sensor, have shown their usefulness in numerous earth observation (EO) applications [11].

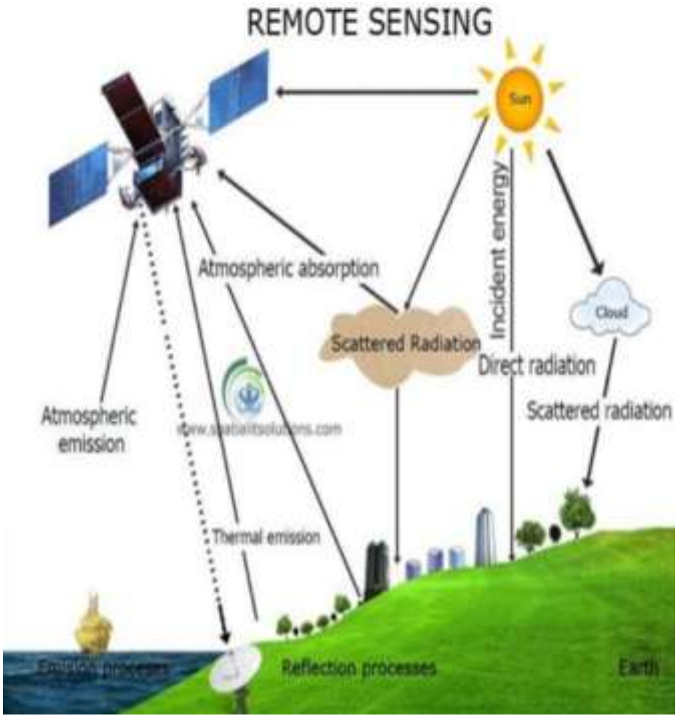

Fig. 1. Remote Sensing Images

In general, the relatively small number of acquisition channels that characterizes multispectral sensors may be sufficient to discriminate among different land-cover classes (e.g., forestry, water, crops, urban areas, etc.) [11]. These sensors are characterized by a very high spectral resolution that usually results in hundreds of observation channels [12]. Remote sensing images provide a wealth of spatial and geographic information and are widely used for forestry, meteorology, hydrology, and military [11].

The quality of Remote sensing images in the fog and haze weather condition is usually dissipated by the scattering of a light before reaching the camera due to these large quantities of suspended particles (e.g. fog, haze, smoke, impurities) in the atmosphere. In order to remove color shift in the image various haze removal methods are used.[12] .

The haze removal methods can be divided into three categories and are discussed below:

A) Additional information approaches

B) Multiple image approaches

C) Single image approaches

1.1 Additional information approaches

For the additional information approaches the given depth information is used. This depth information can be obtained from the other characteristics such as having the knowledge about the tilt, altitude and position of the camera and the approximate distance between the object and the camera.[14].

1.2 Multiple image approaches

Multiple image approaches uses two or more images for the estimation of the depth. The two images used can be of same scene but should have different polarization degree which is used to get the depth information [13].

1.3 Single image approaches

Single image approaches for the fog/haze removal uses approximation and assumptions. These methods use a single image for the restoration of the image along with the key assumptions [13]. Various types of single image approaches are discussed below:

a) Dark Channel Prior

This channel is based upon the assumptions of "dark pixels" which have very low intensity in at least one color channel(R,G,B) This dark channel prior method helps to improve the quality of image [13].

The dark channel prior is based on the observation on fog-free outdoor images that there is at least one color channel having very low intensity at some pixels.[16]

b) Genetic Algorithms

Genetic Algorithms (GAs) are adaptive heuristic search algorithm and is based on the evolutionary ideas of natural selection and genetics. As such they represent an intelligent exploitation of a random search used to solve optimization problems. The main operations under genetic algorithm is mutation , crossover and selection.[15].

c) The Guided Image Filter

This performs edge-preserving smoothing on an image, using the content of a second image, called a guidance image, to influence the filtering. There are two types of filters viz. bilateral and trilateral filtering. These specific filtration smooth's illustrations or photos without having impacting perimeters, by way of the non-linear mix of neighborhood photo values.[3].

d) Adaptive Histogram Equalization (AHE)

AHE is a computer image processing technique that is used to improve contrast in images. It differs from ordinary histogram equalization in the respect that the adaptive method computes several histograms, each corresponding to a distinct section of the image, and uses them to redistribute the lightness values of the image. It is therefore suitable for improving the local contrast and also helps in enhancing the definitions of edges in each region of an image.[3].

e) Gradient Profile Prior

Gradient profile Prior implies that the prior information of natural images gradients. Gradient profile prior has better capability to preserve the edges. The gradient profile prior use restoration model to restore the haze free image by estimating the air light, transmission map etc.[1].

f) Evolutionary Computation, differential evolution (DE)

DE is a method that optimizes a problem by iteratively trying to improve a candidate solution with regard to a given measure of quality. The idea behind the method of differential evolution is that the difference between two vectors yields a difference vector which can be used with a scaling factor to traverse the search space. The strength of differential evolution's approach is that it often displays better results than a genetic algorithm and other evolutionary algorithms and can be easily applied to a wide variety of real valued problems despite noisy, multi-modal, multi-dimensional spaces, which usually make the problems very difficult for optimization.[17].

2. LITERATURE SURVEY

Various researchers have present distinct techniques to remove the haze from remote sensing images.

Rajavel, et al.(2010)[10] presented Image dependent brightness preserving histogram equalization technique which preserves the brightness and enhance the local contrast of image.it suffers from halo and gradient reversal artifacts. He ,et al.(2011)[9]developed a Single haze removal using dark channel prior technique for removing the artifacts by soft matting but this technique was not applicable for large images. Xu et al.(2012)[8] proposed Fast image de-hazing using improved dark channel prior for haze removal .This technique was based upon fast bilateral filtering instead of soft matting. This technique suffers from halo artifacts. Shui et al.(2012)[7] proposed Image Haze Removal of Wiener Filtering Based on Dark Channel Prior.

This technique didn't perform better in some light bright area of the image. Ding, Tong, et al.(2013)[6] presented Efficient directional based image de-hazing using quad trees, this technique was with different concept but could not remove the problems of artifacts in larger images. Then Atul Gujral et al.(2014) [5] proposed Haziness Analysis to overcome the problems of previous techniques. This technique was not suitable for objects which were opaque. Rahul Singh et al.(2105) [4] developed Dark channel prior with gradient prior law to preserve the edges and reducing the gradient reversal artifacts .Main feature of this technique was able to restore the detail information of image. Dilbag, Vijay, et al(2017)[3] developed Dehazing of remote sensing images using FPDE based trilateral filter with adaptive histogram equalization technique to reduce the artifacts. This technique minimizes the various artifacts related to haze removal techniques [1].

Therefore in this paper and in all previous papers, the restoration value and lower bound to transmission map has been taken statically as 0.95 and 0.1 respectively. Sukhdeep, Navleen, et al.(2017)[2] et al. proposed Efficient image de-hazing using multi-objective differential evolution ,this technique tried to improve the parameters which were needed to enhance the visibility of image.

This technique also helps in minimizing the various artifacts. This technique uses dark channel prior which is not suitable because it gives annoying halo and gradient reversal artifacts.[1].Dilbag, Vijay, et al(2018)[1] developed a novel de-hazing model for remote sensing images using gradient domain based weighted guided filter for removing the gradient reversal artifacts. This technique gives minimum number of gradient reversal artifacts, color halo artifacts, edge distortion rate as compare to previous techniques.

Comparison of existing techniques along with their features and drawbacks is explained in Table 1.

TABLE 1. COMPARISON TABLE OF EXISTING TECHNIQUES

Sr No.	Author Name	Year	Technique	Features	Drawbacks
1	Dilbag, vijay, et al[1].	2018	A novel de-hazing model of remote sensing images.	Use Gradient profile prior to remove haze. reduce edge distortion rate.	Minimum number of halo and gradient reversal artifacts.
2	Sukhdeep, navleen, et al.[2]	2017	Efficient image de-hazing using multi-objective differential evolution.	Use dark channel prior along with multi-objective differential evolution.	Dark channel prior suffers from halo artifacts; Use of gradient profile prior is being ignored.

3	Dilbag, Vijay, et al[3]	2017	De-hazing of remote sensing images using FPDE based trilateral filter.	Use of dark channel prior along with FPDE based trilateral filter.	Suffers from Gradient reversal artifacts, the restoration value and transmission map is taken statistically.
4	Rahul Singh et al.[4]	2015	Brief review on image de-noising technique	Improve visibility and keep details of image.	Not suitable to surveillances and some unnamed vehicle systems.
5	Atul Gujral et al.[5]	2014	A Novel defogging technique for de-hazing images	No user interaction is needed and computation speed is fast.	Not effective with objects which are opaque.
6	Ding, Tong, et al.[6]	2013	Efficient directional based image de-hazing using quad trees.	Use of sub divided quad tree.	Not efficient for large images having large image gradients.
7	Shui et al.[7]	2012	Image Haze Removal of Wiener Filtering Based on Dark Channel Prior	Medium filtering based on dark channel, It also minims MSE.	Doesn't perform better in some light bright area of the image.
8	Xu et al.[8]	2012	Fast image de-hazing using improved dark channel prior	Based upon fast bilateral filtering instead of soft matting.	Suffer from Halo artifacts.
9	He ,et al.[9]	2011	Single haze removal using dark channel prior	Effective for small images due to soft matting.	Transmission map is not smooth, blocking artifacts.
10.	Rajavel ,P et al[10].	2010	Image dependent brightness preserving histogram equalization	Improve contrast of hazy image while preserving brightness.	Halo and gradient reversal artifacts.

3. Gaps in Literature

Haze removal algorithms become more beneficial for numerous vision applications. It has been originated that the most of the existing research have mistreated numerous subjects. Following are the various research gaps concluded using the literature survey:-

1. The presented methods have neglected the evolutionary techniques i.e. Ant colony optimization, Negative selection algorithm or fuzzy logic kind of techniques to improve the quality of the Haze removal algorithms.

2. In most of the existing techniques, the restoration level and lower bound to transmission map are limited to 0.95 and .0.1 respectively.

3. The particle swarm optimization suffers from poor convergence speed.

4. The most of researchers has ignored the integrated approach i.e multi objective differential evolution and gradient profile prior to improve the visibility of image.

3. CONCLUSION

Haze removal techniques are used to remove the haze , which is caused due to impurities present into atmosphere. This paper studies various haze removal methods used in the area of digital image processing. While compared with others 'A novel de-hazing model of remote sensing images' and 'Efficient image de-hazing using multi-objective differential evolution' gives better results. To enhance the visibility of hazy image gradient profile prior and multi-objective differential evolution can be combined to give more improved results.

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