An Automatic Satellite Image Enhancement using Advanced Genetic Algorithm

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***Abstract*- Satellite images are clearless due to large number of reasons. Henceforth the necessary information which serves as input in the images will be unclear. Image enhancement is the technique which can improve a satellite image information which is hidden. Image enhancement method is used to improve the quality of the image to get useful information. General issues of satellite images are enhancement of gray-scale/colour, noise, artifacts, distortion, image large size, resolution, weak colour information, high frequency content and many more. In this paper, sample images before enhancement is taken from satellite and enhancement is done without producing unnatural and unclear images and retaining image with good natural contrast. The principle of preserving the natural basic colours is applied here and the originality of the natural image is retained by properly identifying the non matching ones and discarding them.**

Keywords- GA, FCM, PSNR, MSE, SSIM

1. INTRODUCTION

1.1. Image Enhancement

Image enhancement problem can be formulated as follows: given an input low quality image and the output high quality image for specific applications. The aim is to improve the visual appearance of the image, or to provide a "better" transform representation for future image processing. Carrying out image enhancement understanding under low quality image is a challenging problem because of these reasons. Due to low contrast we cannot clearly extract objects from the dark background. Most colour based methods will fail on this matter if the colour of the objects and that of the background are similar. (Kandelwal, 2013).

1.2. Image Enhancement Using Genetic Algorithm

The aim is to enhance the quality of the image using genetic algorithm. The application of genetic algorithm towards increasing the quality of the image is a model of machine learning. The GA is adopted to achieve better results, faster processing times and more specialized applications.

1.3. Working Cycle of a Genetic Algorithm

Genetic Algorithm(GA) is a population based probabilistic search and optimization technique, which works based on the mechanics of natural genetics and Darwin's principle of natural selection. The GA was introduced by Prof. John Holland of the University of Michigan, AnnArbor, USA, in 1965 (J.H.Holland, 1992).

The working principle of the GA (K.Pratihar) has been explained as follows :

- The GA starts with a population of initial solutions generated at random.
- The fitness/goodness value of each solution in the population is calculated. It is generally designed to solve a maximization problem. Thus a minimization problem has to be converted into a maximisation problem.
- The population of solutions is then modified using different operators, namely reproduction, crossover, mutation and others.

- All the solutions in a population may not be equally good in terms of their fitness values. An operator named reproduction is utilised to select the good solutions using their fitness value. Thus it forms a mating pool
- The mating pairs are selected at random from the pool which may participate in crossover. In crossover there is a exchange of properties between the parents and as a result of which new children solutions are created.
- The term mutation means sudden change in parameter. Thus if a solution gets stuck at the local minimum this operator may help to come out of this situation
- After the reproduction, crossover and mutation are applied one generation of a GA is completed. Different criteria may be used to terminate the program , such as the maximum number of generations , a desired accuracy in the solutions and others.

Following is the simple Genetic Algorithm which includes GA operators like selection, crossover and mutation. (R.K.Bhattachariya, 2012)

```
Function GeneAlgo()
{
  Initialize population;
  Calculate fitness function;
  While (fitness value!= termination criteria)
   {
          Selection;
          Crossover;
          Mutation;
          Calculate fitness function;
     }
}
```

2. RELATED WORK USING GENETIC ALGORITHM

The aim of this method is to enhance the contrast of image that measures the fitness of individual by evaluating the intensity of spatial edges included in the image.

By ability of genetic algorithm to search a solution in a global space a relation between input gray levels and output gray levels is determined to convert an original gray image to an enhanced image with a good contrast. Applying of genetic algorithm to a image consist of the representation of individual chromosome, the genetic operation like reproduction, mutation, crossover and finally selecting the best fitness values of individuals.

2.1. Towards Automatic Image Enhancement Using Genetic Algorithms

This concept (A.Rosa, 2000) was introduced for a new automatic image enhancement technique based on real coded genetic algorithm. The method applies to each pixel at location (x,y) the following transformation.

$$g(x,y) = \left(k \frac{M}{\sigma(x,y) + b} \right) [\, f(x,y) - c.\, m(x,y)] + m(x,y)^{a} \qquad 0.5 < k < 1.5 \tag{1}$$

Where m(x,y) is the gray level mean computed in a neighbourhood centered at (x,y) and having nxn pixels. M is the global mean of the image, f(x,y) is the gray level intensity of input image pixel at location (x,y),while g(x,y) is the pixels output gray-level intensity value, at the same location, b not equal to zero allows for zero standard deviation in the neighbourhood, c not equal to zero allows for only a fraction of the mean m(x,y) to be subtracted from the original pixel gray-level, while the last term might have a brightening and

smoothing effect on the image. The parameters of the method a,b,c and k are the same for the whole image. The task of the GA is to find the best combination of the four parameters according to an objective enhancement criterion and fitness function.

The fitness criteria is given by the equation (2).

$$F(x) = \log(\log(E(I(x)))).\, n\_edgels(I(x))/\, H\_sizexV\_size\, .\, H(I(x)) \quad (2)$$

F(x) denotes the fitness function applied to chromosome x, I(x) denotes the original image I with the transformation T applied. E(I(x)) is the sum of the intensity of the edges detected with a sobel edge detector. n_edgels denotes the number of edge pixels as detected by the sobel edge detector. H(I(x)) is a measure of the entropy in the image I(x).H_size, V_size are the horizontal and vertical sizes (number of pixels in each direction) of the image. A combination between binary tournament that has a constant and high selection pressure with a K elitist scheme is used for selection. Arithmetic crossover is used to produce the children. Arithmetic crossover is defined as in the equation (3).

$$X_1^{\,0} = ax_1^{\,p} + (1-a)\, x_2^{\,p}, x_2^{\,0} = (1-a)\, x_1^{\,p} + a x_2^{\,p} \quad (3)$$

where $x^{p}_{\{1,2\}}$ are the parent chromosomes and $x^{0}_{\{1,2\}}$ are the offspring and a is a randomly generated number drawn from a uniform distribution. PCA mutation is used as the mutation operator that has very good capabilities in maintaining higher levels of diversity in the population.

2.2. Drawbacks

The existing methods for image contrast enhancement was studied (Archana, 2012) and found that the its speed is very slow as compare to other search algorithm because it works globally and the originality of the image was not preserved and taken into account.

3. PROPOSED WORK

Satellite image processing is one of the peak areas in the field of computer science research. Images taken by satellites are possibly degraded due to climate, weather and other factors. Satellite image enhancement and restoration is scientifically possible by applying image processing and other soft computing techniques.

A satellite image before enhancement is loaded and the following preprocessing is done.

- The CIE lab conversion is done to identify the natural colors and increase the color range wherein the clarity increases.

CIE L*a*b* (CIELAB) is a color space specified by the International Commission on Illumination (French Commission internationale de l'éclairage, hence its CIE initialism). It describes all the colors visible to the human eye. It is designed to approximate human vision. It aspires to perceptual uniformity, and its L component closely matches human perception of lightness it can be used to make accurate color balance corrections by modifying output curves in the a and b components, or to adjust the lightness contrast using the L component.

Color opposition correlates somewhere between the optical nerve and the brain, retinal color stimuli are translated into distinctions between light and dark, red and green, and blue and yellow. CIELAB indicates these values with three axes: L*, a*, and b*.The advantage of CIE color space is that they are all device independent, unlike RGB or CMYK colour spaces which are related to a specific device (camera, scanner, or printer, etc.) and/or material type (paper, ink set, film emulsion or lighting, etc.). The RGB and CMYK spaces usually do not cover the entire visible colour spectrum . The CIE also specify lighting conditions.

- Denoising is done by using fuzzy c means algorithm

Impulse noise is generally introduced into images while transmitting and acquiring them over an unsecure communication channel. In the case of satellite or TV images it can be caused through atmospheric disturbances. In other applications, it can be caused by strong electromagnetic fields, transmission errors, etc. Images play an important role in extracting hidden information in the field of satellite imaging, remote sensing and military surveillance. Raw images received from satellite, radar, space probes and aircrafts can be corrupted by impulse noise. The intensity of impulse noise has the tendency of being either relatively high or relatively low. Thus, it could severely degrade the image quality. The human visual system is very sensitive to the amplitude of noise signals, thus noise in an image can result in a subjective loss of information. Therefore, Image denoising is one of the most important preprocessing steps in fields such as defence and security applications, astronomy, medical imaging, and forensic science, where high quality imaging is needed for analysing images of unique events. Various techniques have been introduced in the literature to filter images corrupted by impulse noise, including non-linear, fuzzy and combined filters.

- A fuzzy C Means Algorithm is best suited for denoising

The fuzzy c-means (FCM) algorithm is a clustering algorithm developed by Dunn, and later on improved by Bezdek. It is useful when the required number of clusters is pre-determined; thus, the algorithm tries to put each of the data points to one of the clusters. What makes FCM different is that it does not decide the absolute membership of a data point to a given cluster; instead, it calculates the likelihood (i.e., the degree of membership) that a data point will belong to that cluster. Hence, depending on the accuracy of the clustering that is required in practice, appropriate tolerance measures can be put in place. Since the absolute membership is not calculated, FCM can be extremely fast because the number of iterations required to achieve a specific clustering exercise corresponds to the required accuracy. The fuzzy-based image denoising has many advantages over the traditional image denoising techniques. It can handle imprecision and ambiguity (Jaskiran Kaur, 2016)& (Sathik2, 2012)

- Finally enhancement is done by applying histogram equalisation.

This method usually increases the global contrast of many images, especially when the usable data of the image is represented by close contrast values. Through this adjustment, the intensities can be better distributed on the histogram. This allows for areas of lower local contrast to gain a higher contrast. Histogram equalization accomplishes this by effectively spreading out the most frequent intensity values. The method is useful in images with backgrounds and foregrounds that are both bright or both dark.

4. IMPLEMENTATION

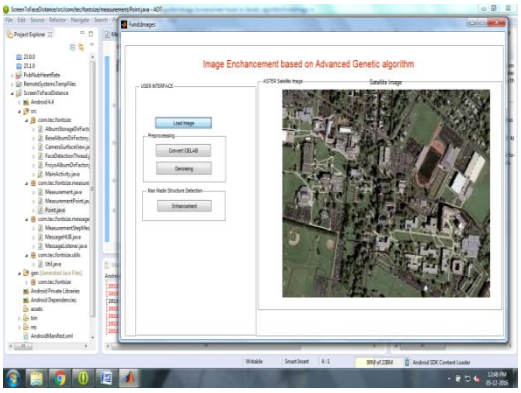


Figure 2. Selected Load Image

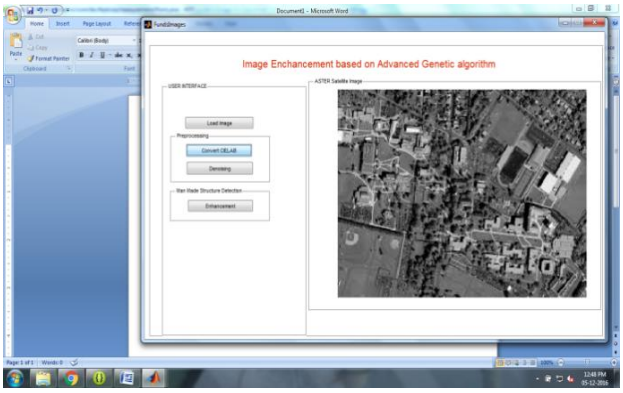


Figure 3. Converted Images

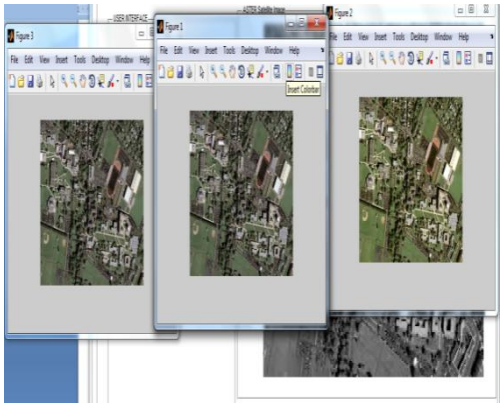


Figure 4. Denoising Images

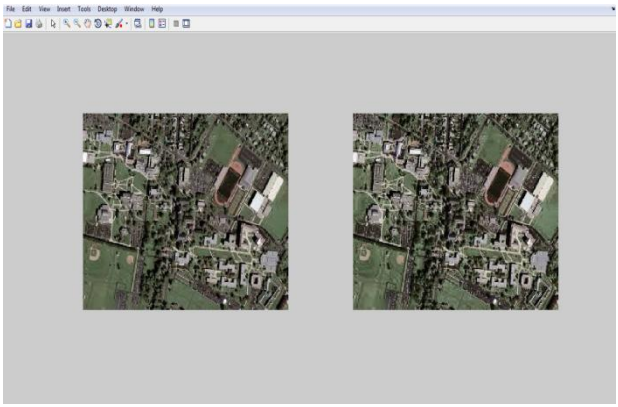
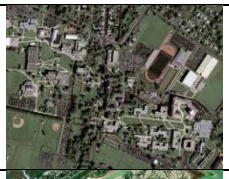


Figure 5. Enhanced output using Advanced GA

Table 1. PSNR, MSE & SSIM VALUES

S.No	IMAGES	PSNR Value		MSE Value	SSIM Value
		Input Image(Original)	Output Image(Enhanced)		
1.		87.7956	88.2975	0.5019	0.9606
2.		94.7511	96.1331	1.3820	0.9598
3.		99.4105	100.5713	1.1608	0.9605
4.		62.8872	63.0328	0.1457	0.9438
5.		106.2797	108.0119	1.7322	0.8079
6.		84.5038	85.4432	0.9394	0.9192
7.		110.4819	110.5175	0.0355	0.9910

5. ANALYSIS TABLE

Image quality assessment consists in modeling the metric between an original (ideal) image and a distorted version of it. The goal is to evaluate and compare the performance of image processing algorithms. After applying some distortion(enhancement) to the original five satellite images the image quality is applied to these images and the results are given in Table 1.

The PSNR block computes the peak signal-to-noise ratio in decibels, between two images .This ratio is often used as a quality measurement between the original and a distorted image. The higher value of the PSNR is the better quality of the reconstructed image. The MSE represents the cumulative squared error between the distorted and the original image. The lower the value of the MSE is represented the high is the quality of the image.The SSIM index is a measuring of image quality based on an initial distortion-free image as reference. It compares two images using information about luminous, contrast and structure. SSIM metric is designed to improve on traditional methods like PSNR and MSE.

6. CONCLUSION

A novel approach is presented for image enhancement. Conventional image enhancement methods suffer from blurring effects while they obtain good level of peak signal to noise ratio (PSNR). The new algorithm based on advanced genetic algorithm aims towards image enhancement while keeping the image originality at a good level. To test the developed algorithm seven satellite images have been used. According to results, the proposed algorithm supplies fair enough level of PSNR,MSE and SSIM values in addition to stop loosing the sharpness and natural level of the test images.

An Automatic image enhancement using Advanced genetic algorithm method enhances image automatically without human interaction. For future works, this can be utilized by combining with other decision making techniques such as neural network, and to modify the algorithm so that it deals with a stream of continually changing training data instead of fixed training data.

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