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Optimization of Edges of an Image using Gravitational Search Algorithm

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Abstract: In this work edges of image have been optimized using Gravitational Search Algorithm. Edge is an essential and extensive feature of an image. Edges of a picture are examined a form of imperative information that can be extricated by use of detectors with distinct techniques. Edge detection is a fundamental step as it is a process of selecting and locating continuity and acute discontinuities in a picture. Gravitational Search Algorithm is a prominent population based search method which is inspired by Newtonian gravity. In this paper, comprehensive analysis of edge detection using adaptive thresholding and gravitational search algorithm is used along with adaptive thresholding for edge detection has been performed. Experimental analysis are done on several test images by using these two methods which shows that edge detection using adaptive thresholding along with GSA optimization method has superior image quality and better Structural Similarity Index Metric (SSIM) value.

Keywords: Gravitational Search Algorithm (GSA), Adaptive Thresholding, Edge Detection, Structural Similarity Index Metric (SSIM).

1. INTRODUCTION

Recently, with the evolution of image processing technology it is used quite a lot. Most of our essence reticulate with a technological structure is encased in an image processing device is configured on. One of the most relevant areas in the image processing is an edge detection process. Detection of edge is the vital in image analysis, image segmentation, texture feature extraction and shape feature extraction [1]. Edge detection is defined as the technique of selecting and locating acute discontinuities in an image. It is used to locate an edge of an image. Thresholding can be defined as in which a portion of image is taken and by context all pixels of intensity values higher than a threshold is set to a forepart value and for a background value all the entire remaining pixels are set. Although the ordinary threshold operator for pixels uses an overall threshold. But in adaptive thresholding different variations of threshold are applied dynamically over the image. This is more refined version of thresholding which contain changeable lightning circumstances in the image which arise by cause of firm brightness gradient or darkness [2].

Gravitational search algorithm is an optimization stemmer inspired by Newtonian gravity. In this algorithm, it consists of searcher agents which are collation of masses. Masses collaborate using a direct mode of connection, through gravitational force of attraction. The stemmer is operated by accurately regulating the gravitational and inertia masses and individual mass exhibits a solution. The lighter mass move towards heaviest mass and then the heavier mass exhibits a best result in the search space [3].

2. LITERATURE SURVEY

In [1] authors presented solution using Newtonian Gravitational Edge Detection using Gravitational Search Algorithm and claimed to have optimization as per theoretical approach. However, there was no justification on the edge optimization. Search stemmer and universal law of gravity have been used for this algorithm. In this approach the edges are detected by applying the law of gravity and then squatting of agents is determined using gravitational search stemmer. It presents a minimal set of input data which is processed and though that it is conclude that the process becomes faster and memory competent [4]. S. Jansi *et.al*. proposed adaptive thresholding using ACO for edge detection and compared it with different edge detection algorithms by measuring their performance evaluation which demonstrates that SNR of proposed algorithm has better performance than other methods [5]. Kokila Jandial *et.al*. proposed approach which was capable to identify the edge pixel in a picture. It concludes that particular picture pixel is a celestial body with a mass expressed by its gray scale intensity. This approach was focused on optimization of edge detection problem [6]. Yusra A.Y. Al-Najjar and Den Chen Soong compared various techniques for measuring the quality of the image such as PSNR, HVS, SSIM, UIQI. This presents that the good IQM must be correct and concordant in anticipating the quality [7]. In [8] authors have reported document image binarization using GSA and TCM, to improve the PSNR.

3. ADAPTIVE THRESHOLDING BASED EDGE DETECTION

Thresholding is imperative technique in image segmentation. Thresholding is known as adaptive thresholding when a distinctive sample of threshold is used for distinct regions in the image. Local or dynamic thresholding is also known by adaptive thresholding. The adaptive threshold factor is used in irregular lightning surroundings where we segment an agile foreground part object against the background part object. As in traditional thresholding, the full image illumination is

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considered but in many lightning conditions darkness or blurring of light originates thresholding problems. Adaptive thresholding implements binary thresholding by evaluating particular pixel corresponding to its local neighborhood.
Generally, adaptive thresholding consider an input as a color picture or gray scale picture and performs straightforward implementation which results a binary image in the output which depicts the edge information. For every pixel in the picture, a threshold has to be computed. If the intensity value of pixel is less than the threshold, it is assigned to the background value, otherwise it is assigned as the foreground value [8].

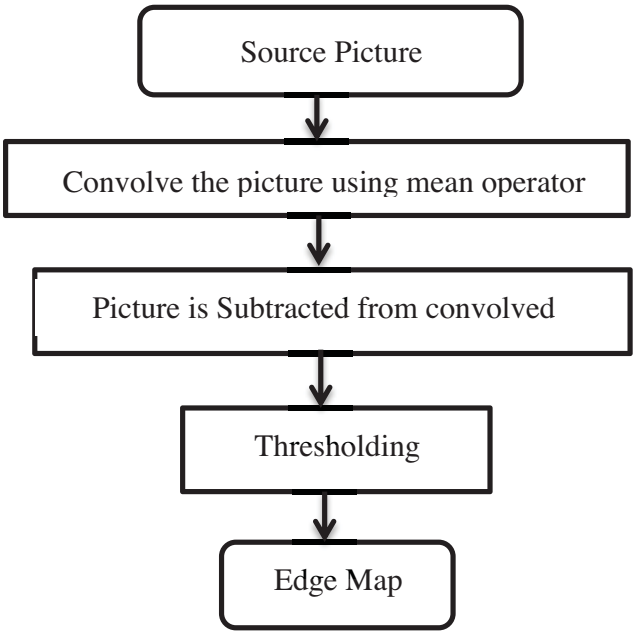

Fig: 1 Flowchart of edge detection using Adaptive Thresholding

4. GRAVITATIONAL SEARCH ALGORITHM

The invention of the Gravitational Search Algorithm was done by Rashedi et al., and has been used to solve optimization problems. It is well established that the algorithm, which are population based heuristic algorithm work on the law of gravity and mass interactions. This algorithm includes collection of search agents, which relates with each other through the gravity force. The agents are treated as objects and their performance is measured by their masses. The force generated by gravity causes a complete global movement where all objects move towards other objects with greater masses. The masses are actually obeying the law of gravity as shown in Equation (1) and the law of motion in Equation (2)

$$F = G\,(M1M2 / R2) \quad \ldots\ldots\ldots (1)$$

$$a = F/M \quad \ldots\ldots\ldots (2)$$

According to Equation no.1, F represents gravitational force magnitude, G stands for constant of gravity, M1 and M2 represents the mass of the first and second objects and R defines distance among the two objects. Equation no.1 represents that in the Newton gravitational law, the gravitational force among two objects is directly proportional to the product of their masses and inversely proportional to the square of the distance among the objects. In reference to equation no. 2, the Newton's second law presents that the acceleration is determined by the force that acts on the object and by mass of the object.

In GSA, the various criteria which are described by agent are named as position, inertial mass, active gravitational mass, and passive gravitational mass. In this the location of the mass presents the result of the problem, whereas the gravitational and inertial masses are calculated using a function which is named as fitness function. The stemmer is operated by regulating the gravitational and inertia masses, whereas individual mass exhibits a result. Masses move towards the heaviest mass. Thus, the heaviest mass shows a best result in the search space [9]. GSA algorithm primarily includes of the following steps:-

Search space identification.
Initialization.
Agent estimation using fitness function.
Update G(t), best(t), worst(t) and $M_i(t)$for i=1,2,….N.
Calculation of complete force in all possible directions.
Finding of acceleration and velocity.
Update agent's position.

Repeat all these steps until the stop criterion is approached. End.

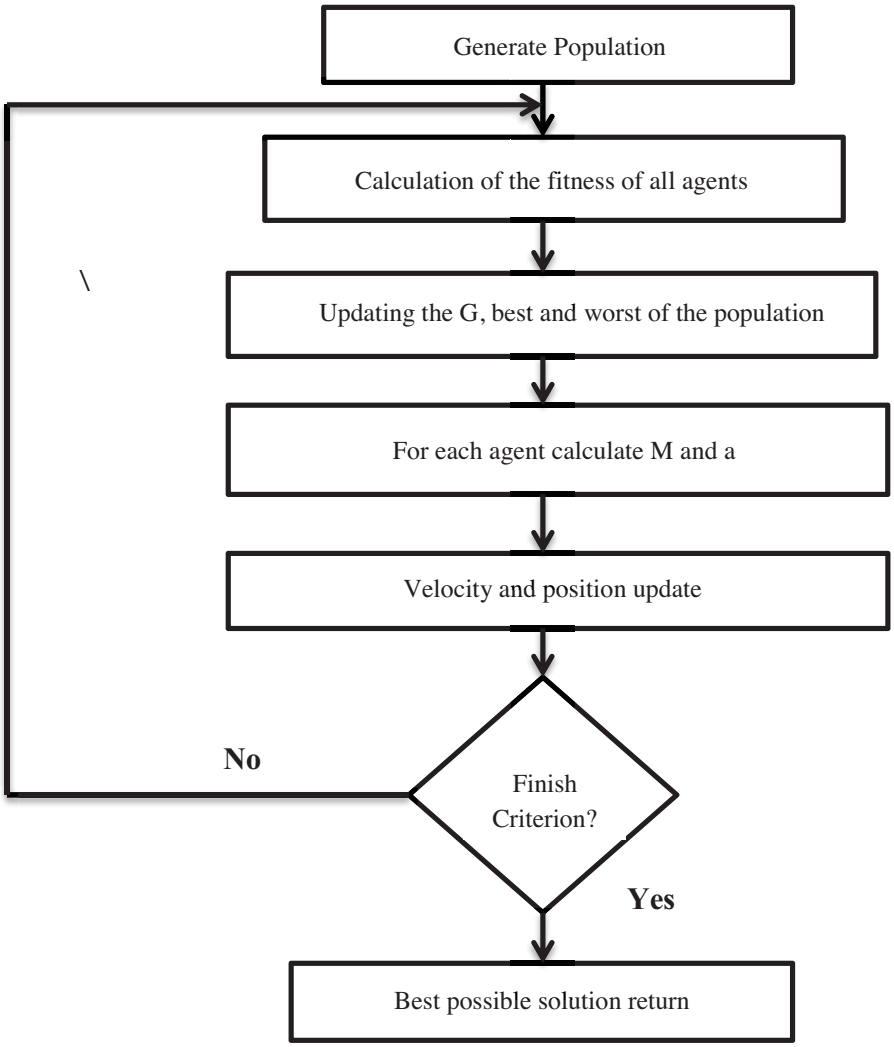

Fig: 2 Flowchart of GSA

Proposed algorithm, which has been tested for the time complexity and other such parameters has been narrated below:

Algorithm

Step 1 Reading of the image.
Step 2 Iinitial processing of the image.
Step 3 Evaluation using fitness function.
Step 4 Update parameters- G (t), best (t), worst (t) and M (t).
Step 5 Calculation of total force in all possible directions.
Step 6 Now, using adaptive Thresholding.
Step 7 Set the Threshold value.
Step 8 Evaluate the SSIM parameter with the edge map image.

5. Parameter Used for Comparison

In this paper, SSIM is used to measure the image quality of each edge, which were considered in both methods.
Structural Similarity Index Measurement (SSIM): The structural similarity index is a technique used for measuring picture quality. It measures picture aridity which depends on an original compressed or distortion-free picture as retrospection. It figures out the quality of a distorted image by computing the correlations in luminance, contrast and

structure locally between the reference and distorted pictures and averaging these quantities over the full image. It is a revised version of the universal image quality index. The SSIM index value varies between 0 and 1. The value nearest to 1 shows the maximal accordance with the original images [10]. The SSIM Index quality assessment is leaned on the estimation of three premises which are luminance, contrast and structural. The global index is a multiplicative consolidation of the three terms.

$$\boldsymbol{SSIM}(\boldsymbol{x},\boldsymbol{y}) = [\boldsymbol{l}(\boldsymbol{x},\boldsymbol{y})]^{\alpha}.[\boldsymbol{c}(\boldsymbol{x},\boldsymbol{y})]^{\beta}.[\boldsymbol{s}(\boldsymbol{x},\boldsymbol{y})]^{\gamma}$$

The given equation is clear for the terms used in multiplicative features of the image.

6. EXPERIMENTAL ANALYSIS

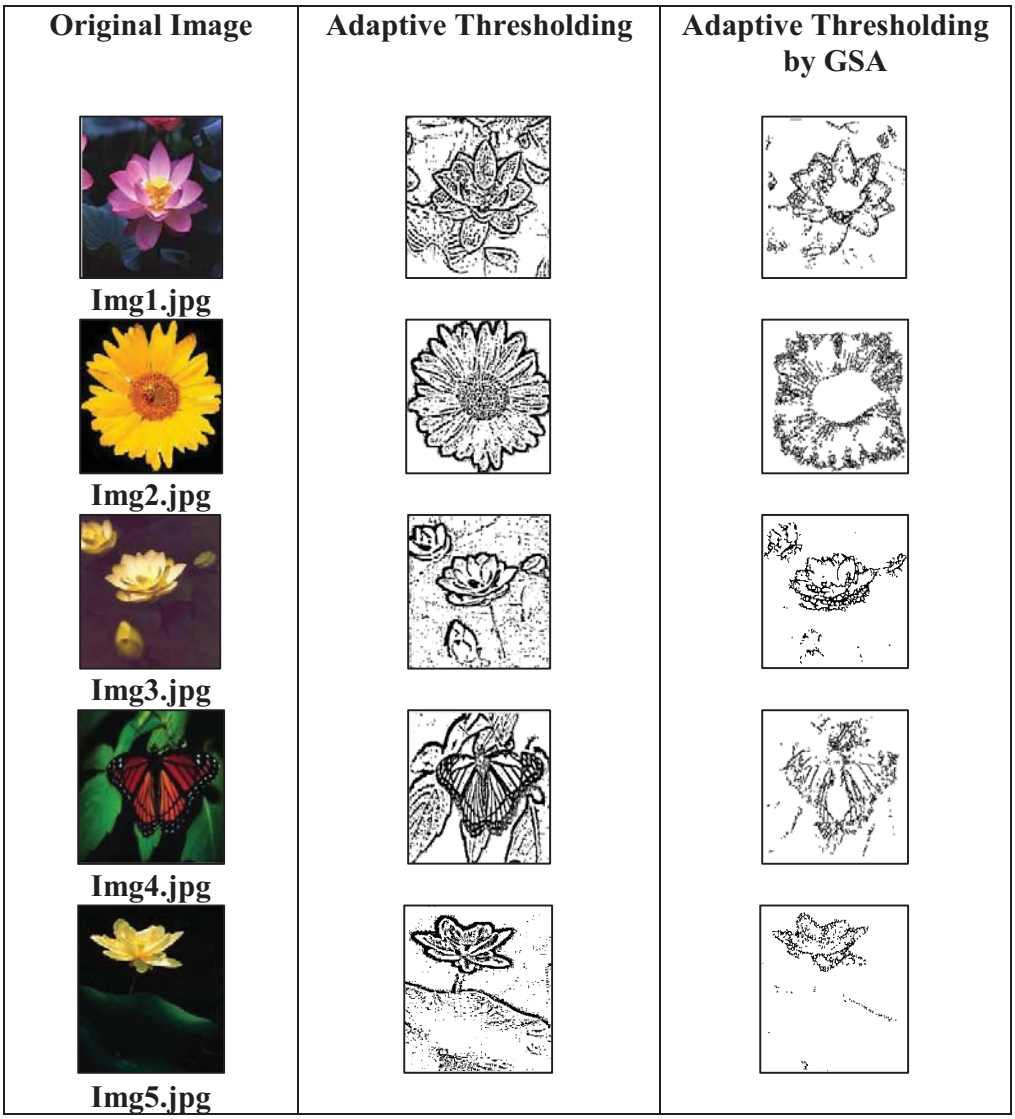

Figure 3: experimental results using adaptive thresholding

The experimental images as shown in figure above clearly shows the improvement at various stages and has produced results as per the prediction.

7. RESULT ANALYSIS

The implementation has produced the results, which can be analysed as has been given in the table below. It is clear from the analysis that the thresholding technique as discussed is better and viable.

Image	Adaptive Thresholding	Adaptive Thresholding by GSA
Img1.jpg	0.87029	0.96797
Img2.jpg	0.87254	0.91648
Img3.jpg	0.86142	0.96394
Img4.jpg	0.88534	0.98659
Img5.jpg	0.85798	0.98377

8. CONCLUSION

Edge is a basic feature of an image. In this paper, the investigation has been done on image quality on a selected test images using edge detection by adaptive thresholding and gravitational search algorithm along with adaptive thresholding based on Structural Similarity Index (SSIM) parameter, which demonstrates that using gravitational search algorithm with adaptive thresholding has a superior image quality and better Structural Similarity Index (SSIM) value.

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