Image Optimization using Cuckoo Search and Levy Flight Algorithms

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ABSTRACT
The paper aims at solving the issue of image noise and image distortion by providing an algorithm for producing an optimized image with optimum threshold value. It does so by firstly explaining in detail what does optimization actually mean and how optimization relates to the field of image processing and can be applied to images to make it more efficient. It then explains the different image segmentation methods and the different parts that we can obtain as a result of image segmentation. It then explains in detail about what is Cuckoo searching algorithm and how an optimal threshold value can be obtained by the application of meta-heuristic Cuckoo Search algorithm via using the famous concepts of Levy Flight optimization. It also explains about the obligate brood parasitic behavior of some cuckoo species and combines it with the Levy Flight behavior in order to obtain the best possible results. As result, we developed an algorithm using a combination of all the algorithms mentioned above as a solution to the issue of image noise, image sizing and image optimization. The algorithm so suggested does this while reducing the size of the image, without compromising on either the quality or the detailing of the image. The paper also intends to calculate the 'Mean Squared Error' and 'PSNR' value of the squared error image in order to compare the performance of our algorithm with the earlier proposed methods. In the end, the paper also dwells into some of the applications of Image Optimizations in different fields of technology like biometric finger print scanning, steganography and visual cryptography to name a few.

General Terms
Optimization, Cryptography, Algorithm, Exponential

Keywords
MSE, PSNR, Cuckoo search, Levy Flight, Meta heuristics, Makarov property.

1. INTRODUCTION
The advancement in technology has touched new heights in such a way that every problem has numerous solutions to it. This advancement has brought an ease in our day to day life to some extent. However, with every positive aspect there are always certain drawbacks associated with it. One of the major drawbacks can be described as not having the optimum result to a certain problem. And there in comes the role of techniques that can be used to optimize the results to certain problems. Optimization being an ultimate goal is quite difficult to achieve and can be described as a technique or a certain practice which helps in making a design or a system as effective or perfect as feasible. In other words, optimization can also be described as selecting the best solution among the plethora of solutions available to a certain issue or problem. Optimization Problem consists of two main categories which are completely dependent on the given variable. The two main categories are Continuous and Discrete.

The problem of optimization specially magnifies in the field of imagery. Images have become an integral part of our lives. Earlier text used to be the primary source of information consumption whereas now images have overtaken that place. Images are being produced and used today at an unparallel speed, making the very scale and quantity of images qualify for big data in images and the negative part is that the storage space that one has is very limited and can be extended only till a limit. Hence, therein lies a need to optimize the image size, while keeping the image quality and detailing absolutely similar as before and there is an inherit need to eliminate the noise and outlier pixels in an image, in order to make it more efficient and optimized.

Hence, in order to overcome this problem of making images optimized with best threshold value, this research paper focuses on image optimizations and suggests an algorithm, where the image is compressed to the maximum possible level while keeping the look and feel of an image intact. In order to determine the optimal issues in an image, it requires an approach and analysis which is very vigilant among numerous dimensions. Image optimization can be used in various fields such as medical, finance, education, and Photoshop.

Optimization Problem in an image starts with the concept of Image segmentation. Image segmentation can be described as a technique or a procedure in which a creative image is divided or separated into unique classes or groups. Various variety and quality of solutions can be obtained as a result of segmenting an image into numerous parts or module, where the quality of every class of image is very varied and poles apart. Nowadays, concepts and algorithms inspired from environment, also known as "meta heuristic algorithms", have become immensely popular. Meta- heuristic algorithms can be described as higher level procedures or technique designed to select a procedure which provides good solution that may not be accurate, yet approximates the solution to an optimization problem. These algorithms are considered when classic or traditional approaches are inefficient or are not able to find any exact solution. The proposed meta-heuristic algorithm known as Cuckoo Search is inspired by the arrangement of cuckoo by breeding with the help of brood parasitism and searching by Levy Flights. Hence, in this paper, the concept of image segmentation has been combined with meta heuristic algorithm such as Cuckoo Search algorithm through Levy Flight, in order to achieve the best possible optimized image as the output result.

The following sections explain in detail so as to how the concept of image segmentation works, what is cuckoo searching algorithm, how it works and how are we proposing an algorithm, which will be an amalgamation of all these concepts and will be providing an optimized solution in the form of a compressed, yet high quality image, with maximum threshold value as its output.

2. IMAGE SEGMENTATION

When an image is divided into meaningful unique classes, groups or structures, each defined on a different definite feature and representing a different classification, it is known as Image Segmentation. The concept of Image Segmentation plays a very pivotal role in various image processing tasks such as analysis of an image, representation of the separated parts, visualization of an object. etc. In past decades, various segmentation techniques and methods have been developed and implemented but majorly, Image Segmentation is broadly classified in the following categories:

Based on threshold – In this category, techniques such as Histogram Thresholding and slicing techniques are used to segment an image. These types of techniques are either applied directly to an image or can be combined with pre and post processing techniques. This type of technique is based on the assumption that the neighboring pixels that lies below or above a certain value or range belongs to the same class or group (are present in the same cluster) [7].

Based on Boundary/Edge – This technique helps in detecting edges in an image which represents the boundaries of an object and are used for the identification of an object or set of objects in an image. It can be very useful in cases where we might want to eliminate a certain noise factor from the image and so, all we need to do is that, eliminate the object boundary of the noise from the rest of the image, giving us the desired output as the result [8].

Based on Region – This sort of technique suggests that the neighboring pixels in the identical or the same region have alike features like grey-value, color-value or texture [9].

Based on Hybrid – Hybrid techniques can be used to incorporate the results of both the techniques based on region as well as boundary [8].

In this paper, we have used the concept of multilevel thresholding. In multilevel thresholding, an image is divided into a gray scale image, which is further divided into a set of images based on its pixels. The pixels with gray values greater than a certain value T are classified as object pixels whereas the others with gray values lesser than T are classified as background pixels. Certain images are divided with each image highlighting a set of objects, while the background remains the same (black and white) whereas some are divided on the other way round. We shall be using the former division types and analyzing the images so obtained for their threshold values. As a result of applying this thresholding concept we get an image with different sets of overlapping regions that identifies with the real world objects [3].

The types of image segmentation can also be seen with the figure 2.1 as depicted below.

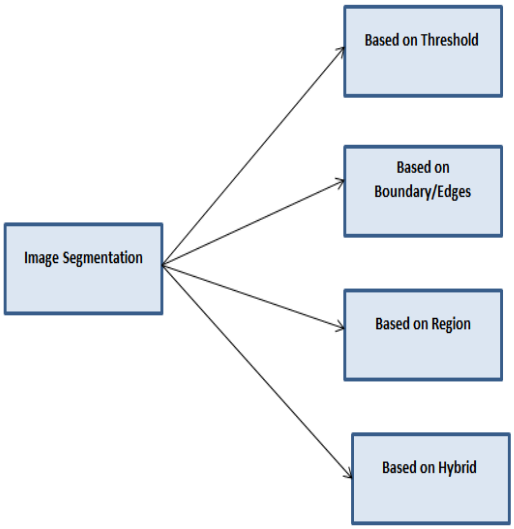

Fig. 2.1 Types of Image Segmentation

3. UNDERSTANDING CUCKOO BEHAVIOUR AND LEVY FLIGHTS

3.1 Cuckoo Breeding Behavior

Cuckoo algorithm is based on Cuckoo bird's breeding behavior, that acts as a meta heuristic and can be used to solve NP hard problem such as that of image optimization. The name of the Cuckoo algorithm is based on the name of the Cuckoo birds, which are famous, not only known because of their captivating attractiveness or soothing sounds they generate, but also because of their aggressive and strategic of reproduction [4].

A lot of species that are not able to form their own nests or breed their own eggs follow a practice called as obligate brood parasitism, in which, they lay their eggs in the nests of other species because they don't have the capability of building their own nests or incubating their own eggs. Obligate brood parasitism is divided into three major categories: intra-specific brood parasitism, Cooperative breeding and nest-takeover. Cuckoo birds also follow obligate brood parasitism for reproduction. They place their eggs in the nest of another species and hope for a successful reproduction. However, if the host bird/species discerns that the eggs they are incubating are not their own, then they either throw those eggs or abandon their current nests and build a new nests at some other place. In order to reduce the possibility of their eggs being discarded and to enhance the chances of their reproductively, some Cuckoo species have evolved over the years in such a way that the female parasitic cuckoos are specialized in mimicking the color and pattern of the eggs of the host species, so that the host species doesn't get to realize that they are breeding eggs of some other species and hence the probability of the eggs getting thrown or abandoned gets reduced significantly. There are also some cuckoo species that coordinate their timing of egg-laying with that of the chosen host species and hatch their eggs slightly earlier than that of the host species' eggs [6].

Parasitic cuckoos frequently choose host species nest, in which they will eventually lay their own eggs. The moment the first cuckoo chick is hatched, the first predisposition step of the cuckoo is to evict or eliminate the eggs of host specie,

which would eventually increase the cuckoo chick's share of food which is being provided to it by the host bird. There are some studies that also signify the fact that there are certain cuckoo chicks that can mimic the call of the host chicks, in order to advance the access to more feeding opportunities.

This concept of aggressive egg breeding in another cluster and greedy approach of getting the most for its own child will be drawn in parallel with the real world optimization problem of that of an image, with different segmentations acting as the nests and the objects and the pixel clusters acting as the group of hosts in each of the category of segments of the image and hence, shall act as the basis of the algorithm developed and suggested in this research paper [6].

3.2 Levy Flights

Levy Flights algorithm was originally introduced by the French mathematician Paul Levy in 1937. It can be described as the random behavior or walk, in which, the steps that one take are defined in terms of the step's length. It consists of shorter as well as longer jumps. It can be used to traverse, plot and predict the path of certain flying species as well as simulate the path of a flight, making deductions on the data possible, as the data and the object obey Makarov's properties and are usually caustic in nature. It can also be used to describe the motion of light and plot its path. Levy Flight objects also obey an exponential behavior, giving them a scale invariant property. This very fact can be used to model data for exhibiting/ showing clusters [1].

Hence, Levy flights behavior can be used as a meta heuristic for situations consisting of studying a cluster of data and deducing meaningful information out of it. Therefore it can be applied to the case of image optimization pretty successfully as the clusters of different objects and pixels can be studied, analyzed and its behavior can be limited with the help of Levy flight concepts. Levy Flight meta heuristics can not only be used for image optimization but can also be used in wide variety of fields for simulating random or pseudo- random phenomenon and finds optimal searching results in a myriad of different application fields ranging from something as wide as concepts of biology and physics to something as basic and essential as cryptography concepts, to something as serious and important as earthquake detection and analysis, it finds an application in it all [2].

4. CUCKOO SEARCHING ALGORITHM

Cuckoo Searching consists of three major rules which are as follows:

1) Each Cuckoo tries its best to lay one egg at a time and place its egg at a randomly chosen nest.

2) The most excellent nests with highest excellence of eggs will carry over to the next generations.

3) The number of obtainable host nests is fixed and if the egg laid by the cuckoo is discovered by the host bird then the egg is discerned by host specie with a probability of

$pa \in [0, 10]$

In order to simplify meaning of the final rule, the last assumption states that it can be adjusted by a fraction 'pa' of the n host's nests that are eventually replaced by the new nests.

When considering the problem of maximization, the quality or fitness of a solution can be proportionate to the value of objective function. Fitness, in other forms can also be described as similar to the fitness function in other genetic algorithms [4].

We can consider the following representations that each egg in a nest represents a particular solution, and consequently, every new egg being put in the nest represents a new solution. The aim of the algorithm is to use a better and innovative solution known as cuckoos in order to replace the weaker and not so good solutions. Presently, we should consider the approach which is simpler, that is, each nest has only one egg [4].

Steps in general Cuckoo Search algorithm are mentioned in detail below and also shown in schematic diagram in figure 4.1 below:

Step: 1 Initialize the controlling parameters like n which is the number of host nets, upper bound and lower bound.

Step: 2 Initialize the random population of host nests.

Step: 3 Calculate the fitness value of each nest and choose the best among the nests.

Step: 4 Generation of news nests with the help of Cuckoo Search via Levy Flight Algorithm.

Step: 5 Evaluate the fitness value for each new nets and choose the best among the new nests.

Step: 6 Comparison of the chosen nests and keep the best solution.

Step: 7 Optimize with the best solution.

5. ALGORITHM IMPLEMENTATION

Using the concepts of Cuckoo searching and Levy flight explained above, we have developed an algorithm for providing efficient image optimization results as its output. The step wise implementation of the suggested algorithm is explained below in detail:

STEP 1 - The first step is to read an image that is colored and convert the given and chosen image into its grayscale equivalent image. The function used for the conversion of a colored image into a grey scale image is as given below:

```
rgb2rray function.grayI = rgb2gray(imread(fn));
```

STEP 2 - In the second step, the initial random population (threshold) will be generated and its upper as well as lower bounds are defined as shown:

```
Lb=0;
Ub=255;
for i=1:10,for j=1:I
nest (i,j) = round((Lb+(Ub-Lb).* rand (size (Lb))));
```

STEP 3 - After the generation of initial set of population, the best solution (threshold) among the set of generated populations is selected and used to segment the gray scale image initially. The best solution is selected by using the following code:

```
a=0;

b=0;
```

```
c = zeros (1, 10);
d = zeros (1, 10) ;
for k=1:10
 a=0; b=0;
 for j=1:k
  [c (k), d (k) ] = calbest (gi, nest (k, j), a, b, j );
  a =c (k);
  b = d (k); %best solution of each nest
```

STEP 4 - Next step involves the generation of a new population (threshold) with the help of Cuckoo Search via Levy Flight Algorithm. This is done using the following code:

```
c1=0;
d1=0;
 for k=1:10
  for j=1:k
  cuck = levii (nest(k, j),d1,j);
  if cuck ~=z
  [c2 d2] = calbest (gi,cuck,c1,d1,1);
   c1=c2;
    d1=d2;
```

STEP 5 - The concepts of Levy flights are utilized in the generation of the following code for obtaining the optimized threshold values:

```
beta=3/2;
sigma=(gamma(1+beta)*sin(pi*beta/2)/(gamma((1+beta)/2)*
beta*2^((beta-1)/2)))^(1/beta);
 for j=1:k,
  s=n;
  u = randn (size(s)) * sigma;
  v = randn (size(s));
  step = u./abs (v) ^ (1/beta);
  best = curthresh;
  stepsize = 0.01*step * (s-best);
s = s + stepsize * randn (size (s));
  s=round(s);
```

STEP 6 - All the generated solutions via the application of a combination of both the algorithms can be used to segment an image. The code for segmenting an image and calculating the correlation of segmented image is given below:

```
function [gi1] = seg (gi, bestthresh)
[o p] = size (gi);
for i =1:o
  for j =1:p
       if gi (i, j) < bestthresh
            gi1 (i, j) = 0;
       else
            gi1 (i, j) = 255;
       end;
   end;
end;
message = sprintf ( 'Best Threshold Value: %d', bestthresh');
msgbox (message);
end;
```

As a result of the application of the above code, the size of the code is passed into an array and the resultant best threshold value is shown in the message box in the end.

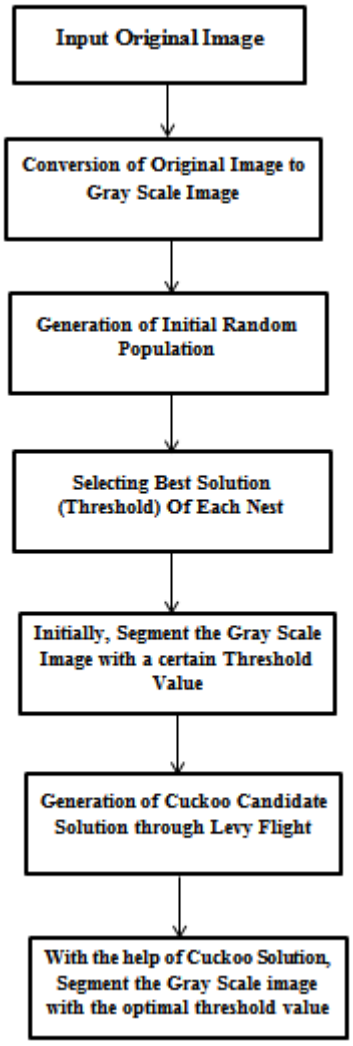

Fig 5.1 Flowchart explaining the working of algorithm

6. MSE AND PSNR VALUE CALCULATION

After the generation of final segmented image, the squared error image is generated, for which grayscale image and final segmented image is used to calculate the PSNR value. PSNR value is the Peak Signal to Noise Ratio value. The higher the PSNR value, the better is the result. The term 'signal' in the PSNR value formula represents the original image whereas the 'noise' is the error in image segmentation process. So if a high PSNR value is found, it indicates good quality segmentation and success. The term ‘MSE- Mean squared

error' in the given formulas is the cumulative squared error between the segmented image and the original image [5].

The code for the calculation of MSE and PSNR values is as shown below:

```
function [sei] = psnr1 (gi, gi1)

format long g;

format compact;

fontSize = 20;

ii = gi;

[rows columns] = size (ii);

 si = gi1;

 sei = (double (ii) – double (si)) ^ 2;

 mse = sum(sum (sei)) / (rows * columns);

 PSNR = 10 * log10 ( 256^2 / mse);
```

7. APPLICATIONS OF IMAGE OPTIMIZATION

Optimization of images is a very important task because the storage space we have is limited and the data that we want to store in it is ever increasing. Hence we need to optimize the images both in terms of size reduction as well as quality enhancement. This will help not only in solving our problem of data crunch but also helps in providing the following applications:

a) Biometric Fingerprint Scanning: In biometric fingerprint scanning, we have to enhance the image so obtained after scanning the finger print, so that we can get a clearer and more noise free image for minutia exploitation and comparison with the one saved in the database. In such a system, real time fingerprint comparison is required and if the image optimization algorithm being used is weak, then no matter now costly equipments we are using, we are going to have a very poor equal error rate and more often than not, are going to make a system which has either high fault rate or high insult rate.

b) Visual Cryptography: It can also be used in aiding the concept of visual cryptography because the extra pixels which are not required, can be removed as a result of the application of the algorithms suggested, and, then, we can embed our secret message or information in the vacant space that has been created as a result of the noise or extra pixel removal. Doing this, the image shall look exactly the same, and even its size might exactly be the same, but it is having some secret information decoded in it in the form of bits encoding or pixel manipulation etc.

c) Social Network Graph Optimization: The given concepts of Levy flight and cuckoo searching can also be utilized in the creation of colonies and optimizing a social networking graph, so that efficient data can be mined from it and it can become more useful. This data being mined as well can be in the form of images in the coming future because the majority of the data that we are consuming today is text. Hence this is an application of future that can utilize the benefits of image optimization.

8. RESULTS AND ANALYSIS

A system generated in MATLAB, using the similar combination of algorithms and codes gives the following results.

Fig 8.1 The original Selected Image

Fig 8.2 Its converted Grey Scale Equivalent

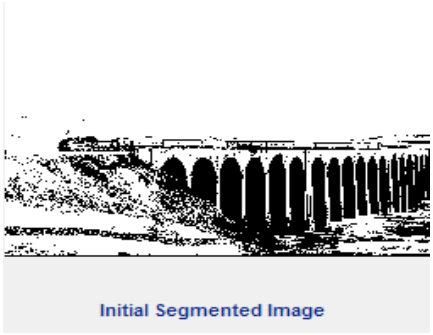

Fig 8.3 Initial Segmented Image

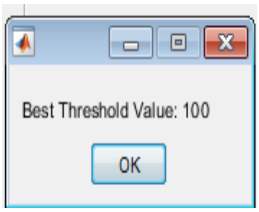

Fig 8.4 A best threshold value of 100 is obtained for the given image.

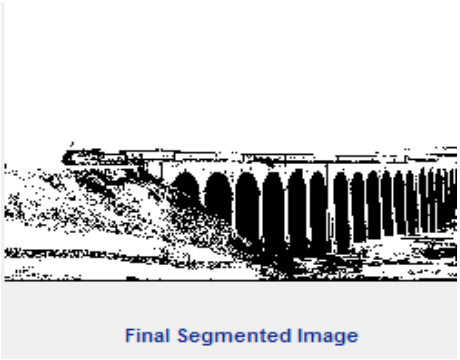

Fig 8.5 The final segmented image on the basis of the best threshold value calculated in the previous stage.

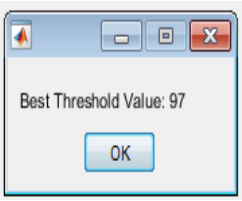

Fig 8.6 Best Threshold value of the Final segmented image is obtained.

Fig 8.7 Squared error image is obatined.

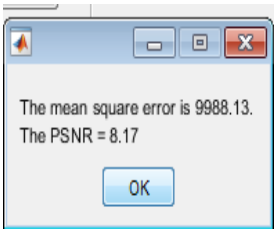

Fig 8.8 PSNR value is otained.

9. CONCLUSION

Therefore, from the algorithm's functionality screenshots and output obtained as showed in the results section above, we can infere that the image being obtained as a result of application of the suggested combination of algorithms is having very less noise in it and also the PSNR value being obtained due to the maniplation is significantly high, representing an excellent solution and a very efficient copy of the image being produced, with significantly less size but similar quality as the parent image, as a result of the algorithm suggested by us.

10. REFERENCES

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