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# Optimal Consistency Measures For Pest Identification Based on Ant Colony Optimization In Agricultural Field

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## Abstract

In recent agricultural field, pest identification causes significant reduction in both quality and quantity of crop cultivation. In order to increase the Production rate of crop, the presence of tiny pests such as aphids, whiteflies, and spider mites which cause leaf deformation is the major problem. Therefore early pest detection is a major challenge in agricultural field. This research employs various image processing & machine learning techniques. At first the captured images are processed for enhancement and then image segmentation is carried out to get Pest target region. Later consistent parameters for pest image segmentation are measured for quality of image such as structural content, peak signal to noise ratio, normalized correlation coefficient, average difference and normalized absolute error. Swarm intelligence is a new approach to solve complicated optimization problem. Ant colony optimization is one of the methods in swarm intelligence is here investigated for Pest image segmentation. Ant Colony optimization was used to extract the region of the pest and also to obtain the optimal consistent parameters of identified pest. The stimulation results for pest image segmentation achieves the accuracy rate were 94%. The algorithm was developed and implemented using MATLAB 7.14 build 2012a.

**Keywords:** Early Pest detection, whitefly Pest, Image segmentation, ACO, Consistency measures

## Introduction

India is the "Land of agriculture" which has many traditional and even a large variety of cultures. Approximately 75% of the Indian population is connected with agriculture. New modern agricultural technique is established in order to the quantity and quality of the yield. But the production is reduced nowadays due to reduction in landscape and also increasing of different kinds of pest, there is no possible way to increase the landscape but there is a possibility to reduce the effects of pest. In most of the cases, pests or diseases are seen on the leaves or stems of the plants like tomato plant, cotton, sugarcane and crop yielding are also reduced due to mealy bug.

Image processing has been proved to be effective tool for analysis in various fields and applications. Image processing along with availability of communication network can change the situation of getting the expert advice well within time and at affordable cost since image processing was the effective tool for analysis of parameters. [1] authors intends to focus on the survey of application of image processing in agriculture field such as imaging techniques, weed detection and fruit grading. The analysis of the parameters has proved to be accurate and less time consuming as compared to traditional methods.

The identification of plants leaves with pests or diseases, symptoms of the pest or disease attack, plays a key role in successful cultivation of crops. Hence to conduct high throughput experiments, plant biologist need efficient computer software to automatically extract and analyze significant content [2] respectively, the applications of color transformation and Neural Networks (NNs) have been formulated for classification of diseases that affect on plant leaves. The detection and recognition of crop pests by many farmers in major parts of the world according to [3] is observation based on the naked eye. This method requires continuous monitoring of the crop stems and leaves, which are expensive, labor intensive, inaccurate for large farms. **[4]** Listed various methods to increasing throughput & reducing the labor arising from human experts in detecting the plant diseases. His research work reveals that different methods are used by different researchers for plant disease detection and analysis. The various techniques demonstrated Self organizing maps & back propagation neural networks with genetic algorithms for optimization & support vector machines for diseases classification.

[5] Demonstrated a cognitive vision approach to early pest detection in greenhouse crops, his work concentrated on low infestation cases, which is crucial to agronomic decision making, particularly on white flies. The application of different image segmentation and clustering algorithm addresses to solve the problem of checking the consistency of different algorithms based on some small number of images or images from one particular field [6] and [7] consider generic segmentation of the medical images which is carried out for different types of medical images and compared using quality measures. [8] Statistical analysis of the sensitivity and consistency behavior of objective image quality measures.

A variety of approaches have been developed for solving image segmentation problems. In these approaches, different methods have defined various cost functions for the task of image segmentation. ACO is first introduced by M. Dorigo [9]. One basic idea of the ACO approach is to use the counterpart of the pheromone trail used by real ants as a medium for communication and as an indirect form of memory of previously found solutions. The ants build solutions constructively guided by heuristic information and the pheromone trails left by ants in previous iterations.

[10] Proposed an algorithm for image segmentation based on the Markov Random Field (MRF) and ACO. An ACO algorithm similar to MAX-MIN ant system for image segmentation based on ACM was developed [11]. This method is usually more effective than the other global optimization algorithms such as genetic algorithm and SA. An improved ACO for fuzzy clustering in image segmentation has been proposed by [12]. In their paper, three features such as gray value, gradient and neighborhood of the pixels, are extracted for the searching and clustering process. They make improvements by initializing the clustering centers and enhancing the heuristic function to accelerate the searching process.[13] present an object segmentation method using ACO algorithm and fuzzy entropy. They have investigated the infrared object segmentation performance of the fuzzy entropy principle and additionally, designed an ACO strategy to find the optimal combination of all the parameters.

[14] put forward a universal texture segmentation and representation scheme based on ACO for image processing, which turned out competitive and quite promising, with excellent effectiveness and practicability especially for images with complex local texture situations. [15] .has proposed a new algorithm for image segmentation based on the concept of aggregation pheromone density, which is inspired by the ants' property to accumulate around points with higher pheromone density.

From this literature review we conclude that early pest detection is a major challenge in crop cultivation. Pest detection was investigated in various papers using image processing techniques. Image segmentation using clustering technique contains many clustered objects, overlapping of objects can cause hiding the structure. Hence it was not appropriate to find consistent parameters for quality of image. Our research aims to propose a new pest detection system using Ant Colony Optimization technique to locate the pest region faster and also to find optimal consistency values

## Need For Pest Segmentation

According to the United Nations' Food & Agriculture Organization, India topped the list of highest Crop cultivation countries, but there is the great economic loss for farmers because of plant diseases and insect pests every year. Greenhouse Crops need to be protected from a variety of different pests, organisms that present a threat to the crop. Tiny pests such as aphids, whiteflies, and spider mites are more likely to infest greenhouse crops than beetles or caterpillars Therefore, it is of great both theoretical and practical significance to develop the automatic identification and diagnose system of Whiteflies insect about 1.5 mm long; found in conjunction with tiny yellow crawlers or green, oval often present on leaves.. It snacks on foliage, coating the leaves with a sticky white residue that shrivels them and attracts black mold to the fruit.

Figure 1 shows leaf affected with whitefly pest. Using whiteflies as the research subject, Ant colony optimization technique was proposed for pest image segmentation and various consistency parameters are measured for the quality of pest segmented image.

**Figure 1:** Leaf affected with white flies

## Overall Scheme of A System

We have taken captured pest image from the agricultural field and loading them as the filter construction image; following acquisition the color transformation structure for the RGB plant pest images was created. A device-independent, L*a*b* (abbreviation for the CIE 1976 (*L**, *a**, *b**) (or CIELAB), which consists of luminosity L*, chromaticity layer a* and chromaticity layer b*, which houses all the color (red-green and blue information) color space transformation structure was applied.

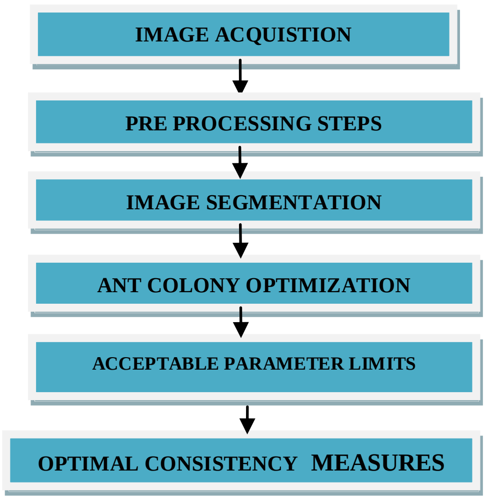


**Figure 2:** Block Diagram For The Proposed Method

Image segmentation is an important step for an automated object recognition system. The goal of segmentation is to simplify and change the representation of an image into something that is more meaningful and easier to analyze. Pest image segmentation is a key step in this procedure [16]. Figure 2 revels the Schematic flowcharts have been developed to addresses the procedure followed for image segmentation.

## ACO Model For Pest Image Segmentatiom

For image segmentation into multiple regions purposes each ant is assigned to a different colony. Ants from different colonies can crossover with the same probability as with ants from the same colony. New ant colony is chosen from the surrounding ants and parent ant colonies by a roulette-well method.

The ants communicate using a chemical substance called pheromone. As an ant travels, it deposits a constant amount of pheromone that other ants can follow. When looking for food, ants tend to follow trails of pheromones whose concentration is higher [17]. There are two main operators in ACO algorithms. These are:

Route construction*:* Initially, the moving ants construct a route randomly on their way to food. However, the subsequent ants follow a probability-based route construction scheme.

Pheromone update: This step involves two important pheromones. Firstly, a special chemical “pheromone” is deposited on the path traversed by the individual ants. Secondly, this deposited pheromone is subject to evaporation. The quantity of pheromone updated on an individual path is a cumulative effect of these two pheromones.

### Acceptable Parameters of ACO For Pest Detection

Ants are supposed to be moving over the grayscale image. Doing so, each ant can occupy only one cell, moreover only one ant can be in one cell. Each ant has certain associated with it probability to move to unoccupied region and to leave a pheromone trace. [18]

1. **Population Size ($\boldsymbol{S}$)** Initial population size is one of the main factors that determine time of iteration. The more ants have populations the longer it takes to compute final result.
2. **Ant’s Attraction ($\boldsymbol{\beta}$)** Increase of attraction parameter causes ants to attract everywhere on image and population size remains very high for a long time.
3. **Ant’s Trail ($\boldsymbol{\rho}$)** With high values of ants’ energy coefficient $\alpha$ ants can travel longer distance prior death at the same time through reproduction increasing the total number of ants. Ants of the same colony tend to occupy multiple pests. With low$\alpha$ values, ants die quickly and segmentation of image does not occur.
4. **Pheromone Information ($\boldsymbol{\alpha}$)** With lower values of ants just move according to gradient, competition decreases and protein spots are not fully covered by pheromone.
5. **Pheromone Evaporation ($\boldsymbol{\kappa}$):** High evaporation of pheromone $K$ leads to lower pheromone level and one colony can easily take over few Pests.

## Consistency Measures

The proposed algorithms have been implemented using MATLAB. The performance measures of image segmentation are analyzed based on 1) Structural Content (SC) 2) Peak Signal to Noise Ratio (PSNR) 3) Normalized Correlation Coefficient (NK) 4)

Normalized absolute error (NAE) 5) Average Differences is considered for study in this work on the original image $x(i,j)$ and on the segmented image $y(i,j)$.

*A. Structural Content (SC)*

It estimates the similarity of the structure of two signals. This measure effectively compares the total weight of an original signal to that of a coded or given. It is therefore a global metric; localized distortions are missed .This measure is also called as structural content. The Structural content is given by Eq. (1) and if it is spread at 1, then the decompressed image is of better quality and large value of SC means that the image is of poor quality.

$$SC = \frac{\sum_{i=1}^{M}\sum_{j=1}^{M} x(i,j)^2}{\sum_{i=1}^{M}\sum_{j=1}^{M} y(i,j)^2} \tag{1}$$

*B. Peak Signal to Noise Ratio (PSNR)*

Larger SNR and PSNR indicate a smaller difference between the original (without noise) and reconstructed image. The main advantage of this measure is ease of computation but it does not reflect perceptual quality. An important property of PSNR is that a slight spatial shift of an image can cause a large numerical distortion, if all the error is concentrated in a small important region. This metric neglects global and composite errors PSNR is calculated using equation (2).

$$PSNR = 10.\log_{10}\left[\frac{\max(x(i,j))^2}{\frac{1}{n_i \times n_j}\left[\frac{\sum_0^{n_i-1}\sum_0^{nj-1}(x(i,j))^2}{\sum_0^{n_i-1}\sum_0^{nj-1}(x(i,j)-y(i,j))^2}\right]}\right] \tag{2}$$

*C. Normalized Correlation Coefficient (NK)*

The closeness between two digital images can also be quantified in terms of correlation function. All the correlation based measures tend to 1, as the difference between two images tend to zero. As difference measure and correlation measures complement each other, minimizing Distance measures are maximizing correlation measure and Normalized Correlation is calculated using equation (3).

$$NK = \frac{\sum_{i-1}^{M}\sum_{j-1}^{N}[x(i,j) \times y(i,j)]}{\sum_{i=1}^{M}\sum_{j=1}^{M} x(i,j)^2} \tag{3}$$

*D. Normalized Absolute Error*

Normalized absolute error computed by equation (4) is a measure of how far is the conversion image from the original image with the value of zero being the perfect fit. Large value of NAE indicates poor quality of the image.

$$NAE = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N}|x(i,j)-y(i,j)|}{\sum_{i=1}^{M}\sum_{j=1}^{N}|x(i,j)|} \tag{4}$$

*E. Average Difference (AD)*

A lower value of Average Difference (AD) gives a “cleaner” image as more noise is reduced and it is computed using equation (5)

$$AD = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}[x(i,j) - y(i,j)] \quad (5)$$

## Simulation Result and Analysis

In this section image segmentation methods are applied to pest image and the various parameter values are calculated. Ant Colony Optimization techniques are simulated for pest image segmentation. Application of ACO for image segmentation depends on acceptable parameter values.

Initial parameters of ACO are chosen according to [19] [20]:$\alpha = 0.025$;$\beta = 3.5$;$\delta = 0.2$;$\eta = 0.07$; $p$ = 1.5; K = 0.01; $\mu = 0.1$ and Population size $S$ is 30 % of the total image size. Simulation is performed in MATLAB environment.

For estimation of ACO model parameters, ant’s behavior is simulated on synthesis pest image which consists of 35 pests, 15 separate pests, 8 pests joined horizontally, 7 pests joined vertically, and 5 pests joined together. A total of 2000 iterations are performed. Figure 3 shows the segmented output of Pest segmentation. During each experiment different ACO parameters are tried in order to improve the further segmentation. The input image is taken as whitefly pest image and it’s processed based on ACO acceptable parameters and various population sizes.

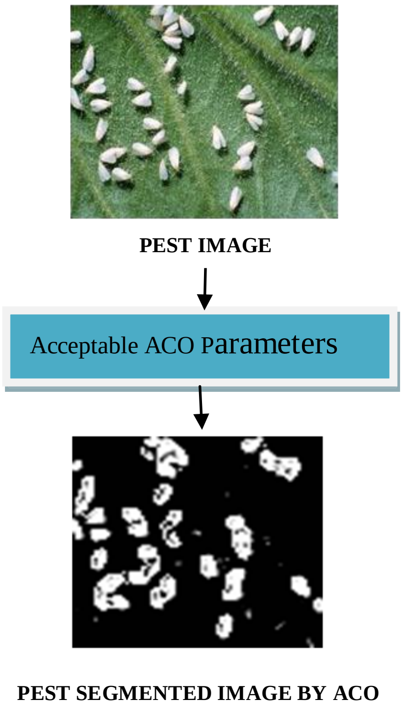


**Figure 3:** ACO Segmented Output

The result of Pest segmented image by ACO are presented in table 1, the population size of 30% image in 1000 iteration shows the complete segmented use of ACO to obtained the optimal consistency values and the various parameter values are calculated.

**Table 1:** Pest Segmentation By ACO

| **N** | **PERFORMANCE MEASURES** | | | | |
|---|---|---|---|---|---|
| 500 | **PSNR (dB)** | **SC** | **NK** | **NAE** | **AD** |
| | 38.65 | 1.007 | 0.98 | 0.041 | 0.187 |
| **1000** | **39.23** | **1.015** | **0.99** | **0.021** | **0.129** |
| 2000 | 38.84 | 1.008 | 1.00 | 0.039 | 0.084 |

N indicates number of iterations

The standard PSNR value of image will be in the range of 25 to 40db, the small value of PSNR means the image is of poor quality, SC with value spread at 1, indicates a better quality image. Large value of NAE, NK and AD indicates poor quality of the image. Structural content is a global measure, which compares the total weight of the segmented image and input image, is 1.007 for 500 iteration, 1.015 for 1000 iteration and 1.008 for 2000 iteration. The structural content with value spread at 1 indicates a better quality image and it is very close to 1 for 1000 iteration ACO output. Normalized correlation gives closeness between the input and segmented image and is obtained as 0.98 for 500 iteration, 0.99 for 1000 iteration and 1.00 for 2000 iteration respectively. This value tends to 1 if the difference between the images is zero and from the computed values, it is observed that for the 1000 iteration ACO segmented images obtained highly correlated to the original images. NAE which is a measure to study the quality of approximation of the images is 0.041, 0.021, and 0.039 for 500, 1000, 2000 iterations ACO respectively. The simulated value of Average difference is 0.187 for 500 iteration, 0.128 for $1000^{th}$ iteration and 0.084 for 2000 iteration, the observed results shows that the proposed ACO provides good quality of segmented image in 1000 iteration. The stimulation result of PSNR shows that the segmented image for 500 iteration is the lowest value of PSNR 38.65 dB, for 1000 iteration ACO segmented image as 39.23dB and for 2000 iteration as 38.84dB. Practically it is in the range of 25 to 40dB hence 1000 iteration ACO shows highest value than others. From the simulation results it's observed that ACO technique for pest image segmentation shows optimal consistent performance measures

**Table 2:** Accuracy Rate of Segmented Image

| Population Size | Iteration | Segmented pest % |
|---|---|---|
| 30% | 500 | 89% |
| | 1000 | 94% |
| | 2000 | 91% |

Table 2 indicates the accuracy rate of pest segmentation using ACO with different iterations. On taking consideration for 30% population size of the original pest image, totally 2000 iteration was performed and various accuracy rates are achieved from the segmented result. In various level of iteration, 500 iteration shows 89% of accuracy rate, 1000 iteration achieves 94% of accuracy rate and 2000 iteration achieves 91% of accuracy for pest segmentation. Comparing the entire accuracy rate for various iteration of 30% population sizes we conclude that 1000 iteration achieves better pest segmented percentage of 94.

## Conculsion and Future Work

This research proposed the solution for optimal consistent values of pest image segmentation using Ant colony Optimization technique. The performance of ACO segmentation is measured for various parameters such as Peak signal to noise ratio (PSNR), Structural Content (SC), Normalized Correlation (NK), Normalized Absolute Error (NAE) and Average Difference (AD). The quality measures are enhanced for the segmented images through the Ant colony Optimization technique. The future research is in direction of comparison of ACO methods with neural network optimization models.

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