Image Processing Using Ant Colony Optimization

[1]Syed Hauider Abbas,[2] Dr Sanjay Kumar Agarwal,[3]A.V.Shukla,[4] Nazish Siddiqui
[1] Phd Reserch scholer,[2] Professor,[3] Lecturer,[4]Lecturer
[1,2] Department of Computer Science & Engineering ,Shri Venkateshwara University,India
[3,4] Integral University,India

Abstract:

Ant colony optimization is a technique for optimization that was introduced in the early 1990's.Ant colony optimization(ACO) is one of the most recent techniques for approximate optimization.The inspiring source of ACO algorithms are real ant colonies.Ant colony optimization is a technique which can be used for various applications. Ant colony Optimization is an optimization technique that is based on the foraging behaviour of real ant colonies. Ant colony optimization is applied for the image processing which are on the basis continuous optimization. This paper de als with the various tasks of image processing which could be achieved with the help of Ant Colony Optimization (ACO) an important field of soft computing.Ant colony optimization (ACO) is a technique which can be used for various applications.Ant colony Optimization is an optimization technique which can be used for various applications.All these techniques are parallel computational techniques which aim to handle imprecise, incomplete, non-linear and complex data. ACO, a field of SC, is a computational intelligence based approach which is used to solve combinatorial optimization problem. The simplicity and optimal approach of ACO has led its applicability to routing, scheduling, sub-set, assignment and classification problems. Focus of the this paper is onto the use of Ant Colony Optimization in the field of Image Processing. Application/Improvements: Edge detection, edge linking, feature extraction, segmentation and image compression are the various image processing tasks in which ACO has been applied successfully. The details pertaining to each of the approach have been discussed. Benefits of using ACO over the conventional techniques have also been presented. Ant colony optimization algorithms have been applied to many combinatorial optimization problems, ranging from quadratic assignment to protein folding or routing vehicles and a lot of derived methods have been adapted to dynamic problems in real variables, stochastic problems, multi-targets and parallel implementations. It has also been used to produce near-optimal solutions to the travelling salesman problem. The first ACO algorithm was called the ant system and it was aimed to solve the travelling salesman problem, in which the goal is to find the shortest round-trip to link a series of cities.The general algorithm is relatively simple and based on a set of ants, each making one of the possible round-trips along the cities.The simplicity and optimal approach of ACO has led its applicability to routing, scheduling, sub-set, assignment and classification problems.

Keywords:

Ant Colony Optimization (ACO), Soft Computing Image processing,, CACO (Continuous ant Colony optimization).

Introduction:

Image processing is a somewhat broad term in modern IT that refers to using various means to process or enhance Images.Image processing is a Set of computational techniques for analyzing, enhancing, compressing, and reconstructing images. Its main components are importing, in which an image is captured through scanning or digital photography; analysis and manipulation of the image, accomplished using various specialized software applications; and output (e.g., to a printer or monitor).Optimization problems are of high importance both for the industrial world as well as for the scientific world.Examples of practical optimization problems include trains cheduling, timetabling,shape optimization,telecommunication network design,or problems from computational biology.The research community has simplified many of these problems in order to obtain scientific test cases such as the well-known traveling sales man problem(TSP).

Image processing has extensive applications in many areas, including astronomy, medicine, industrial robotics, and remote sensing by satellites.The ant colony optimization algorithm is a probabilistic technique for solving many problems which can be reduced to finding good paths through graphs. Although real ants are blind, they are capable of finding shortest path from food source to their nest by exploiting a liquid substance, called pheromone, which they release on the transit route. Image processing techniques can be applied to commercial, medical, scientific, military and industrial applications.The techniques of soft computing include Artificial Neural Networks, Genetic Algorithms Fuzzy Logic, and Ant Colony Optimization . All these techniques work in a direction to handle uncertainties and decision-making.Initially proposed by Marco Dorigo in 1992 in his PhD thesis, the first algorithm was aiming to search for an optimal path in a graph, based on the behavior of ants looking for a path between their colony and a source of food.

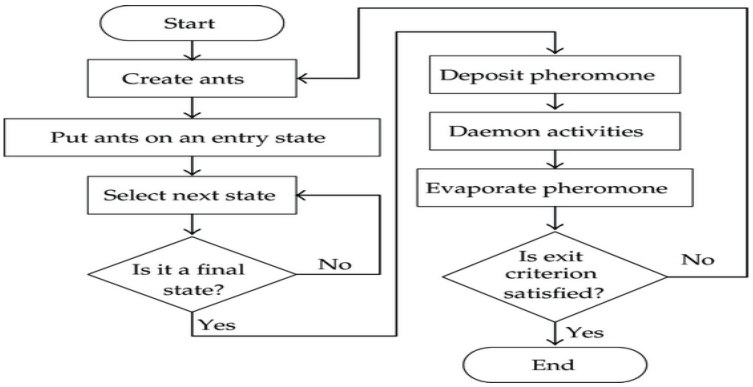

Figure 3.Flow chart of ant colony optimization

The main features of Ant Colony Optimization as follows:

i. Colony based multi agent approach

ii. Distributed and Concurrent System

iii. Search Capabilities

iv. Iterative system

v. Colony based multi agent approach

Scopes And Objectives:

This algorithm is a member of the ant colony algorithms family, in swarm intelligence methods and it constitutes some metaheuristic optimizations.The first algorithm was aiming to search for an optimal path in a graph, based on the behavior of ants seeking a path between their colony and a source of food. The original idea has since diversified to solve a wider class of numerical problems, and as a result, several problems have emerged, drawing on various aspects of behavior of ants.From a broader perspective, ACO performs a model based search and shares some similarities with estimation of distribution algorithms.

The optimization process in ACO based approaches is carried out by a collective system of ants. Each ant contributes to the solution but convergence to the solution is possible by the collective behavior of ants. • Distributed and Concurrent System: The ants work in parallel towards obtaining the solution of any problem. This approach leads a way for solving NP hard problems. Also the ants can exchange information between them to obtain a better solution.

Each iteration in ACO is designed to improve the solution and thus with each passing iteration solution gets better. The reinforcement used after each iteration of ACO helps to achieve this objective. • Search Capabilities: ACO can explore the entire search space to achieve global search capabilities. Also the pheromones are updated by each ant on each arc while constructing a partial solution. So a local search could be applied in ACO which helps to improve the solution. This step of local search is an optional step but as suggested in3 , it improves the overall performance of the algorithm Three variations of ACO were proposed in the beginning for solving TSP problem – ant density, ant quantity and ant cycle algorithm. The major difference in ant quantity, ant density and ant cycle algorithms lies there approach to update pheromone levels. In case of ant quantity and ant density algorithms pheromones are updated after every move whereas in ant cycle algorithm this updation takes place after all the ants have constructed tour4 . The general process of an ACO algorithm is depicted in the flowchart Any optimization problem could be solved using ACO if the problem could be represented using a graph in the discrete search space with all the transitions represented in a valid way. Among other necessary factors are5 : • The

mechanism to update pheromones in order to accommodate the positive feedback, • Mechanism to represent and construct the solutions, • Constraints defined over the problem so that the method constructs only feasible solutions, • An evaluation function which serves as a measure for the generated solutions, and • Termination condition. In the current paper we have given the application of ACO to different areas of image processing and discussed how the imprecise information and decision making is handled in images using ACO. The tasks that have been reviewed and discussed include edge detection, edge linking, feature selection, segmentation and compression. The subsequent sections cover the details of each of the areas of image processing using ACO.

Objectives:

In computer science and operations research, the **ant colony optimization** algorithm (**ACO**) is a probabilistic technique for solving computational problems which can be reduced to finding good paths through graphs. **Artificial Ants** stand for multi-agent methods inspired by the behavior of real ants. The pheromone-based communication of biological ants is often the predominant paradigm used.Combinations of Artificial Ants and local search algorithms have become a method of choice for numerous optimization tasks involving some sort of graph, e.g., vehicle routing and internet routing. The burgeoning activity in this field has led to conferences dedicated solely to Artificial Ants, and to numerous commercial applications by specialized companies such as AntOptima.

As an example, Ant colony optimization is a class of optimization algorithms modeled on the actions of an ant colony. Artificial 'ants' (e.g. simulation agents) locate optimal solutions by moving through a parameter space representing all possible solutions. Real ants lay down pheromones directing each other to resources while exploring their environment. The simulated 'ants' similarly record their positions and the quality of their solutions, so that in later simulation iterations more ants locate better solutions.One variation on this approach is the bees algorithm, which is more analogous to the foraging patterns of the honey bee, another social insect.

Ant Colony optimization is a technique which is used for image processing such as edge detection, image compression, image segmentation, image enhancement etc. As ACO is used for optimization of continuous problems, so it is used for various applications of image processing which shows continuous behaviour. The Ant Colony optimization gives the optimal solutions which are further processed to find the actual results. It gives many outputs on different threshold values. The shortest path of ants has more pheromone than longest paths. So the pheromone updating information is necessary in ACO.

1.Edge Detection

Edge detection is a fundamental procedure in image processing,machine vision,and computer vision. Its application area ranges from astronomy to medicine in which is olatingthe objects of interest in the image is of a significant importance. However, performing edge detection is a non-trivial task for which a large number of techniques have been proposed to solve it. This paper investigates the use of Ant Colony Optimization a prominent set of optimization heuristics to solve the edge detection problem. We propose two modified versions of the algorithm Ant Colony System (ACS) for an efficient and a noise-free edge detection.

Edge detection is a fundamental process in analyzing images. It attempts to find points at which the image brightness has discontinuities. These discontinuities allow changes in pixels intensities which may define the boundaries of an object. Applying edge detection may reduce significantly the amount of data to be processed by filtering out the information that is less relevant and preserving the important structural properties of an image. Therefore, edge detection is involved as an essential stage in a wide range of applications. Examples include medicine applications, pattern recognition,machinevision,image analysis,automotive applications, and others. Furthermore, edge detection should be performed in a reliable way as the validation and the efficient completion of the following stages in the image processing rely on it. At the same time, obtaining ideal edges from real life images with a moderate complexity is a challenging task. The edge detection techniques based on ACO use a number of ants to move on the image. This movement leads to the construction of a pheromone matrix. Edge information at each pixel is represented by an entry in the pheromone matrix. Variation of the intensity values in the image is the key to the movement of ants

2. Edge Linking

Conventional image edge detectors always result in missing parts of the edges. Broken edge linking is an image improvement technique that is complementary to edge detection,where the broken edges are connected to form closed contours in order to separate the regions in the image. In this paper, Ant System (AS) algorithm is modified for edge linking problem. As input, a binary image obtained after applying the Sobel edge operator is used. The proposed method defines a novel fitness function dependent on two variables: the grayscale visibility of the pixels and the length of the connecting edge, in order to obtain effective solution evaluation. Another novelty is of applying the grayscale visibility matrix as the initial pheromone trails matrix so that the pixels belonging to true edges have a higher probability of being chosen by ants on their initial routes, which reduces

computational load. The results of the experiments are presented to confirm the effectiveness of the proposed method.In an ACO based approach has been used to link these broken edges. The approach works on the fact that each pixel in an image is connected to its 8-neighborhood pixels. The distance between adjacent pixels is estimated from the original image.

3. Segmentation

Image segmentation is a complex visual computation problem, which refers to the process of distinguishing objects from background. Ant colony optimization (ACO) is a cooperative search algorithm inspired by the behavior of real ants. In order to achieve an approving performance, we use ACO global optimization algorithm to solve image segmentation problems.Image segmentation can be defined as the process of partitioning a digital image into small segments. These smaller segments are more meaningful and could be analyzed easily which thus simplifies the processing of complete image. In this process every pixel is labeled and the pixels which possess similar visual characteristics are assigned the same label. The task of segmentation seems to be simple but certain factors such as illumination variation, image contrast, image noise, diversity and complex nature of images makes it challenging. Numerous approaches like thresholding, clustering, compressionbased, histogram-based, edge detection, region growing, watershed transformation and model based segmentation have been proposed in literature for segmenting an image. Clustering is the most favorable method for segmentation and could be applied to variety of situations. This may lead to a large number of local minima. In this approach an image is viewed as a set of multi-dimensional data which can be classified into different parts on the basis of certain predefined criterion. Improvements in clustering techniques could be obtained by integrating it with fuzzy theory, neural networks and evolutionary techniques like ACO. Enormous approaches have been proposed in the literature in order to increase the accuracy and reduce the time.

4.Image Compression

Image compression is minimizing the size in bytes of a graphics file without degrading the quality of the image to an unacceptable level.Images are an important form of data and are used in almost every application. Images occupy large amount of memory space. Image compression is most essential requirement for efficient utilization of storage space and transmission bandwidth. Image compression technique involves reducing the size of the image without degrading the quality of the image. A restriction on these methods is the high computational cost of image compression. Ant colony optimization is applied for image compression. An analogy with the real ants' behavior was presented as a new paradigm called Ant Colony Optimization . ACO is Probabilistic technique for Searching for optimal path in the graph based on behavior of ants seeking a path between their colony and source of food. The main features of ACO are the fast search of good solutions, parallel work and use of heuristic information, among others. Ant colony optimization is a technique which can be used for various applications.

The main aim of image compression is to remove the redundancies in order to efficiently utilize the transmission bandwidth and the storage space. A raw image contains Mbs of data, which is reduced by image compression techniques. There are two types of image compression techniques - lossy compression and lossless compression. In lossless techniques no information is lost and hence the original image can be exactly reconstructed but the compression ratio is low. In case of lossy compression techniques there is a loss of

information so that if the compressed image is decompressed then it would not be identical to original image but would be closer to it. In lossy technique Compression ratios are high but image quality gets degraded. Various lossy compression techniques are available like-transformation coding, vector quantization, fractal coding and block truncation coding. It has been found that higher compression ratios are produced by fractal coding techniques. Fractal coding technique works by dividing the starting image in to small, non-overlapping, square blocks, which are also called parent blocks. Each parent block is divided into 4 sub blocks or child blocks and each child block is compared against a subset of all possible overlapping blocks of parent block size. Larger block is determined by finding the lowest difference between it and the child block. A grayscale transform is calculated to match intensity levels between large block and child block precisely. This Fractal Image Compression (FIC) is based on the similarities of various blocks in an image. Ant Colony optimization is a technique which is used for image compression. The Ant Colony optimization gives the optimal solutions which are further processed to find the actual results

Conclusion:

Ant Colony optimization is a technique which is used for image processing such as edge detection, image compression, image segmentation, image enhancement etc. . As ACO is used for optimization of continuous problems, so it is used for various applications of image processing which shows continuous behaviour.
ACO has immense potential in solving various image processing tasks including edge detection, edge linking, feature extraction, segmentation and image compression. It is used for various applications of image processing which shows continuous behaviour. The Ant Colony optimization gives the optimal solutions which are further processed to find the actual results. It gives many outputs on different threshold values. The shortest path of ants has more pheromone than longest paths. So the pheromone updating information is necessary in ACO.The current paper gives in-depth analysis of ACO applied over image processing tasks thus giving future directions of research. Many other latest techniques like Cuckoo Search have been used for optimization purposes. Ant Colony System is more successful since it avoids long convergence time by directly focus the search in a neighborhood of the best tour found up to the current iteration of the algorithm.

References:

[1] shahab Kamali, Jaroslav Opatrny, “A Position Based Ant Colony Routing Alogorithm for Mobile Ad-hoc Networks”,JOURNAL OF NETWORKS, VOL 3, NO 4, APRIL 2008.

[2] Alirezae Rezaee, ”Extracting Edge of Image with Ant Colony”,Journal of ELECTRICAL ENGINEERING , VOL. 59, NO.1,2008,pp.57-59

[3] C.Naga Raju, O.Rama Devi, Sharada Mani, Sanam Nagendram, “An Improved Ant Colony Optimization Technique by using Fuzzy Inference Rules for Image Classi cation and Analysis”, International Journal of Advanced Engineering & Application, Jan. 2010 .

[4] M.Dorigo,G.D.Caro,L.M.Gambardella, “Ant algorithms for discrete optimization Artificial Life”,5(2):pp.137-172,1999

[5] ANNAVERONICAC.BATERINA,CARLOSM.OPPUS,”Ant colony optimization for Image Edge Detection” Department of Electronics and Communications Engineering Ateneo de Manila University Katipunan Avenue , Loyola Height,Quezon City Philliipines.

[6] Jing Tian, Weiyu Yu, Shengli Xie,”An Ant Colony Optimization Algorithm For Image Edge Detection”2008 IEEE Congress on Evolutionary Computation (CEC 2008).

[7] Ant Colony Optimization by Marco Dorigo and Thomas Stützle, MIT Press, 2004. ISBN0- 262-04219-3

[8] Marco Dorigo and Thomas Stültze, Ant Colony Optimization, p.12. 2004.

[9] J. Dr´eo, P. Siarry., "Continuous interacting ant colony algorithm based on dense heterarchy". Future Generation Computer Systems, 20(5): pp. 841–856, June 2004.

[10] M. K. Lee, S, W. Leung, T. L. Pun, and H. L. Cheung. "EDGE DETECTION BY GENETIC ALGORITHM."IEEE Transactions on Image Processing, 2000.Proceedings.2000 International Conference (2000), Vol.1, 478-80.

[11]. Tabakhi S, Parham M, Fardin A. An Unsupervised Feature Selection Algorithm based on Ant Colony Optimization, Engineering Applications of Artificial Intelligence. 2014; 32:112-23.

[12]. Khanna K, Navin R. Reconstruction of Curves From Point Clouds using Fuzzy Logic and Ant Colony

Optimization, Neurocomputing. 2015; 161:72−80.

[13].Aghdam Mehdi H, Nasser GA, Mohammad EB. Text Feature Selection using Ant Colony Optimization, Expert Systems with Applications. 2009; 36(3):6843−53.

[14]. Haberstroh R, Ludwik K. Line Detection in Noisy and Structured Backgrounds using Græco-Latin Squares, CVGIP: Graphical Models and Image Processing. 1993; 55(3):161−79.

[15]. Jun S, Dong H. Statistical Theory of Edge Detection, Computer Vision, Graphics, and Image Processing. 1998; 43(3):337−46.

[16]. Ji Q, Robert M. Efficient Facet Edge Detection and Quantitative Performance Evaluation. Pattern Recognition. 2002; 35(3):689−700.

[17]. Prewitt, Judith MS. Object Enhancement and Extraction, Picture Processing and Psychopictorics. 1970;10(1):15-19.

[18]. Chodil, Gerald J, Alan S. Stacked lattice spacer support for luminescent display panels. U.S. Patent No. 4,099,082. 4 Jul. 1978.

[19]. Nalwa, Vishvjit S, Thomas OB. On Detecting Edges, IEEE Transactions on Pattern Analysis and Machine Intelligence. 1986; 6:699−714.

[20]. Ji Q, Robert M. Error Propagation for the Hough Transform, Pattern Recognition Letters. 2001; 22(6):813-23.

[21]. Klarquist, William N, Alan C. Fovea: A Foveated Vergent Active Stereo Vision System for Dynamic Three-Dimensional Scene Recovery, IEEE Transactions on Robotics and Automation.1998; 14(5):755−70.

[22]. Canny J. A Computational Approach to Edge Detection, IEEE Transactions on Pattern Analysis and Machine Intelligence. 1986; 6:679−98.

[23].Rezaee A. Extracting Edge of Images with Ant Colony, Journal of Electrical Engineering-Bratislava. 2008; 59(1):57.

[24].Zhuang X, Mastorakis NE. Edge Detection based on the Collective Intelligence of Artificial Swarms. Proceedings of the 4th WSEAS International Conference on Electronic, Signal Processing and Control. World Scientific and Engineering Academy and Society (WSEAS), 2005.

[25].Nezamabadi P, Hossein S, Esmat R. Edge Detection using Ant Algorithms, Soft Computing. 2006; 10(7):623-28.

[26].Baterina A, Carlos O. Image Edge Detection using Ant Colony Optimization, WSEAS Transactions on Signal Processing. 2010; 6(2):58−67.

[27].Zhang J et al. Ant Colony Optimization and Statistical Estimation Approach to Image Edge Detection. 6th International Conference on Wireless Communications Networking1998; 14(5):755−70. and Mobile Computing (WiCOM), 2010.

[28].Mahani N, Mohamad K, Hosein N. A Fuzzy Difference based Edge Detector, Iranian Journal of Fuzzy Systems. 2012; 9(6):69−85.

[29].Tyagi, Y et al. A Hybrid Approach to Edge Detection using Ant Colony Optimization and Fuzzy Logic, International Journal of Hybrid Information Technology. 2012; 5(1):37−46.

[30].Tao C et al. Image Edge Detection based on ACO-PSO Algorithm, Image. 2015; 6(7).

[31].Sharifi M, Mahmood F, Maryam TM. A Classified and Comparative Study of Edge Detection Algorithms. Information Technology: Coding and Computing, Proceedings. International Conference on IEEE, 2002.
[32].Ghita O, Paul FW. Computational Approach for Edge Linking, Journal of Electronic Imaging. 2002; 11(4):479−85.

[33].Maini R, Himanshu A. Study and Comparison of Various Image Edge Detection Techniques, International Journal of Image Processing. 2009; 3(1):1-11.

[34].De S, Chien CC. Edge Detection Improvement by Ant Colony Optimization, Pattern Recognition Letters. 2008; 29(4):416-25.

[35].Dorrani Z, Mahmoodi M S. Noisy Images Edge Detection: Ant Colony Optimization Algorithm, Journal of AI and Data Mining. 2016; 4(1):77−83.

[36].Khare A, Duttta M. A REVIEW: An Improved ACO Based Algorithm for Image Edge Detection, International Journal of Engineering Research Management Technology. 2015; 2(5):55−64.

[37].Barbosa H. Ant Colony Optimization: Techniques and Applications. In Tech, 2014.

[38].Sivagaminathan, Rahul K, Sreeram R. A Hybrid Approach for Feature Subset Selection using Neural Networks and Ant Colony Optimization, Expert Systems with Applications. 2007; 33(1):49−60.

[39].Erguzel Turker T, Serhat O, Selahattin G, Nevzat T. Ant Colony Optimization based Feature Selection Method for QEEG Data Classification, Psychiatry Investigation. 2014; 11(3):243−50.

[40].Yuanning L, Gang W, Huiling C, Zhengdong Z, Xiaodong Z, Zhen L. An Adaptive Fuzzy Ant Colony Optimization for Feature Selection, Journal of Computational Information Systems. 2014; 7(4):1206-13.

[41].Bolun C, Ling C, Yixin C. Efficient Ant Colony Optimization for Image Feature Selection, Signal Processing. 2013; 93(6):1566−76.

[42].Kanan HR, Karim F, Sayyed MT. Feature Selection using Ant Colony Optimization (ACO): A New Method and Comparative Study in the Application of Face Recognition System. In Industrial Conference on Data Mining, Springer Berlin Heidelberg; 2007. p. 63−76.

[43].Rasmy MH, El-Beltagy M, Saleh M, Mostafa B. A Hybridized Approach for Feature Selection Using Ant Colony Optimization and Ant-Miner for Classification. IEEE, 2012.

[44]. Xiaohan Y, Juha Y, Olli H, TV, Outi S, Toivo K. Image Segmentation Combining Region Growing and Edge Detection. In: Proceedings, 11th IAPR International Conference on Pattern Recognition. Conference C: Image, Speech and Signal Analysis. IEEE; 1992, 3. p. 481−84.

[45].Pavlidis T, Liow YT. Integrating Region Growing and Edge Detection, IEEE Transactions on Pattern Analysis and Machine Intelligence. 1990; 12(3):225-33.

[46].Beucher S. The Watershed Transformation Applied to Image Segmentation. Scanning Microscopy-Supplement; 1992. p. 299.
[47].Collins DL, Terence MP, Weiqian D, Alan CE. Model-Based Segmentation of Individual Brain Structures from MRI Data. In: Visualization in Biomedical Computing, International Society for Optics and Photonics; 1992. p. 10-23.

[48]. Salima O, Batouche M. MRF-Based Image Segmentation using Ant Colony System, ELCVIA: Electronic Letters on Computer Vision and Image Analysis. 2003; 2(1):12-24.

[49]Yu Z, Weiyu Y, Ruobing Z, Simin Y. On ACO-Based Fuzzy Clustering for Image Segmentation. In: International Symposium on Neural Networks, Springer Berlin Heidelberg; 2009. p. 717-26.

[50].Senthil Kumar NK, Kumar KK, Rajkumar N, Amsavalli K. Search Engine Optimization by Fuzzy Classification and Prediction, Indian Journal of Science and Technology. 2016 Jan; 9(2):1−5.

[51].Zhao B, Zhongxiang Z, Enrong M, Zhenghe S. Image Segmentation based on Ant Colony Optimization and K-Means Clustering. In: Porc. of Int. Conf. Automat. Logistics; 2007. p. 459−63.

[52].Niknam T, Babak A. An Efficient Hybrid Approach based on PSO, ACO and K-Means for Cluster Analysis, Applied Soft Computing. 2010; 10(1):183−97.

[53].Han Y, Pengfei S. An Improved Ant Colony Algorithm for Fuzzy Clustering in Image Segmentation, Neurocomputing, 2007; 70(4):665−71.

[54]. Yu J, Sung-Hee L, Moongu J. An Adaptive ACO-based Fuzzy Clustering Algorithm for Noisy Image Segmentation, International Journal of Innovative Computing Information and Control. 2012; 8(6):3907-18.

[55]. Lewis AS, Knowles G. Image Compression using the 2-D Wavelet Transform, IEEE Transactions on Image Processing. 1992; 1(2):244−50.

[56].Nasrabadi NM, Robert AK. Image Coding using Vector Quantization: A Review, IEEE Transactions on Communications. 1988; 36(8):957−71.

[57].Fisher Y. Fractal Image Compression, Fractals. 1994; 2(3):347−61. 61. Delp E, Mitchell O. Image Compression using Block Truncation Coding, IEEE Transactions on Communications. 1979; 27(9):1335−42.

[58].ang H. Fast Image Fractal Compression with GraphBased Image Segmentation Algorithm, International Journal of Graphics. 2010;

1(1);19-28.

[59].Uma K, Palanisamy G, Poornachandran G. Comparison of Image Compression using GA, ACO and PSO Techniques. In: Recent Trends in Information Technology (ICRTIT), 2011 International Conference on, IEEE; 2011. p. 815-20.

[60].Premalatha B, Umamaheswari S. Cuckoo Search Optimization Algorithm based Hardware Task Placement and Routing in CAD of FPGAs Design Flow, Indian Journal of Science and Technology. 2016; 9(6):1−8.

[61]. Senthil Kumar NK, Kumar KK, Rajkumar N, Amsavalli K. Search Engine Optimization by Fuzzy Classification and Prediction, Indian Journal of Science and Technology. 2016 Jan; 9(2):1−5.

[62].Simranjeet Kaur, Prateek Agarwal, Rajbir Singh Rana – Ant Colony Optimization: A Technique used for Image Processing, IJCST, 2, 2, 2011.