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A Survey on Application of Bio-Inspired Algorithms

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***Abstract*- The algorithms that are inspired by the principles of natural biological evolution and distributed collective behaviour of social colonies have shown excellence in dealing with complex optimization problems and are becoming more popular nowadays. This paper surveys the recent advances in biologically inspired swarm optimization methods, including ant colony optimization algorithm, particle swarm optimization algorithm, artificial bee colony algorithm and their hybridizations, which are applied in various fields.**

***Keywords*- Biologically inspired algorithms, Swarm Intelligence, application of Bio-inspired algorithms.**

I. INTRODUCTION

The increasing complexity of real-world problems motivates the researchers to search for efficient methods. Divide and conquer techniques are the one way to solve large and complex problems which has been a practice in research since long time.

Swarms have relatively simple behaviours individually, but with amazing capability of co-ordination and organizing their actions, they represent a complex and highly structured social organization. Examples are bee colonies, ant colonies, mosquito swarms, fish schools, birds, flies and particle swarms.

Swarm Intelligence is a branch of biologically inspired algorithms which is focused on the collective behaviour of swarms in order to develop some meta-heuristics which mimic the swarm's problem solution abilities. Taking the inspiration from success and efficiency of the distributed, co-ordinated and collective behaviour of swarms in real world, researchers have tried to develop sophisticated methods and systems that make use of the techniques of the swarms to find solutions to complex optimization problems[1][2].

Some of the most popular swarm algorithms are inspired are ant colony optimization [3] and particle swarm optimization [4], Bee colony optimization, and algorithms inspired by fish schools [6], gravity and mass interactions [7], as well as different aspects of the behaviour of bees[8, 9], bacteria [10], fireflies [11,12], cockroaches [14], bats [13], and cuckoo birds [15].

II. APPLICATION

Swarms exhibit the behaviour of division of work and cooperation to achieve difficult tasks. Bio-inspired algorithms are used widely in various fields for solving various problem like travelling salesman and graph colouring problems, scheduling and resource constrained problem and optimizing routing in networks. These algorithms are mostly proposed and used for optimizing the search operation, prediction, classification, clustering in Image processing and neural networks, routing, clustering, and scheduling of resources in the field of networking [16]-[25]. Several bio-inspired algorithms has been proposed in field of medicine for performing various tasks, which results in better performance.

This paper surveys the applications of Bio-Inspired algorithms, in various fields, inspired by the behaviour of swarms such as bee colonies, ant colonies, particle swarms and firefly are shown in TABLE I, II, III and IV respectively.

TABLE I
A review on application of algorithms inspired by behaviour of bee colonies

Method	Description
Artificial Bee colony Optimization [26]	A new approach is used for matching templates in digital images using a heuristic ABC Algorithm.
Artificial Bee Colony and Clustering [27]	To find the clusters of an image using ABC based image clustering method.
Hybrid Artificial Bee Colony algorithm and Tabu Search [28]	To solve job shop scheduling problems flexibly, Hybrid ABC algorithm has been proposed in hybrid with Tabu search.
Artificial Bee Colony [29]	A technique proposed to eliminate Doppler noise in the aortic valve and to determine the filter coefficients by using IIR Filter with ABC algorithm.
Artificial Bee Colony algorithm [30]	ABC algorithm is tailored to solve Graph Colouring Problem
Artificial Bee Colony, Graph colouring algorithm [31]	An algorithm proposed to solve the Course Scheduling Problem using a meta heuristic ABC algorithm in hybrid with graph colouring algorithm.
Artificial Bee Colony Optimization [32]	To solve Steiner tree problem, by using a heuristic ABCO algorithm
Hybrid artificial bee col ony algorithm and Bacterial foraging optimization algorithm [33]	To improve the intensification ability of ABC algorithm, it's used in hybrid with Bacterial Foraging optimization algorithm.
Enhanced Artificial Bee Colony Optimization (EABCO) [34]	A method proposed to diagnose the breast cancer using EABCO algorithm. This automatically detects the breast border and nipple position. Then the suspicious regions are identified using bilateral subtraction.

Method	Description
Neural Networks and Bee Colony Optimization [35]	A method for classification of masses in breast DCE-MR images using an Artificial Neural Networks which is trained by a Bee Colony Optimization algorithm.

TABLE II
A review on application of algorithms inspired by behaviour of ant colonies

Method	Description
Ant algorithm [36]	To solve difficult optimization problems and distributed control problems, a new approach has been proposed, which is inspired by the natural behavior of ant colonies.
Ant Colony Optimization [37]	A novel method utilized ACO algorithm to implement feature subset selection and search procedure.
Travelling Salesman problem (TSP), Ant System [38]	A new approach proposed to utilize distributive and positive feedback Ant System to optimize the classical TSP.
Ant colony optimization [39]	To solve discrete optimization problems, Ant Colony Optimization method is used.
Ant Colony Optimization [40]	To segment MRI brain images, Ant Colony Optimization is used.
Fuzzy method and Ant colony optimization [41]	A fuzzy method in hybrid with ACO is used for MRI segmentation.
Improving ant colony optimization [42]	An approach proposed to improve the efficiency of ACO algorithm in brain MR image segmentation.
ACO, Fuzzy and Hybrid Self Organizing Map [43]	To detect tumors in brain by using a Fuzzy method in hybrid with ACO and Self Organizing.
Ant Colony Optimization [44]	A new method using ACO algorithm to segment the brain image.
Ant Colony Optimization and Support Vector Machines [45]	A method proposed to use ACO algorithm for feature set selection and SVM for lymph node classification from Ultrasound images.
Hybrid Markov Random Field with Parallel Ant Colony Optimization and Fuzzy C Means [46]	A novel approach to segment Brain MR Image by finding the optimum label minimizing the MAP estimate, by using Parallel ACO in hybrid with FCM Algorithm.
Markov Random Field method hybrid with Ant Colony System, Genetic Algorithm and Back propagation Network (MRF–ACSGA-BPN), Conventional textural analysis methods [47]	A technique to segment and classify the micro calcifications in mammograms using Ant colony system. Suspicious regions are extracted by segmenting the mammogram image using MRF-ACSGA method. Conventional textural analysis methods like SGLDM, SRDM, GLRDM and GLDM are used for feature extraction and three-layer BPN classifier is used for classification.
Markov Random Field (MRF), Sequential TS-ACS, Hybrid ACS/TS, Sequential ACS-TS algorithms [48]	A hybrid heuristic method proposed for segmenting mammogram image. Hybrid heuristic methods are applied to identify the optimum method, which minimizes the MAP estimate, of the segmented mammogram image using MRF. The Sequential ACS-TS provides the superior solution of all.
Ant Colony Optimization, Bee colony Optimization, Fuzzy C-Means and Genetic Algorithm [49]	Some novel method on Bio-inspired adaptive algorithms like ACO, BCO and Genetic algorithm is introduced for Selection of features extracted from mammogram image. Validation through classification is performed by means of Fuzzy C-Means algorithm.
Spatial gray level dependence method (SGLDM), Ant Colony Optimization, Genetic algorithm [50]	A hybrid method for selection and classification of features extracted from mammogram image. Features are extracted using SGLDM. Feature selection is performed using GA and ACO, which then fed to a three-layer BPN hybrid with ACO for classification.
Bilateral subtraction, Ant Colony Optimization and Genetic Algorithm [51]	A technique is implemented for extraction of suspicious regions using Asymmetric approach. Breast border is detected using GA and Bio-inspired ACO algorithm for nipple identification. Finally suspicious regions are identified by subtracting the images of left and right breast.

TABLE III
A review on application of algorithms inspired by particle swarm

Method	Description
Particle Swarm Optimization [52]	An algorithm to solve course scheduling problem using PSO.
Artificial Bee Colony and Particle Swarm Optimization [53]	To improve the performance of the algorithm using hybrid modified EABC-PSO and OABC-PSO.
Particle Swarm Optimization, Ant Colony Optimization, Genetic algorithm and Spatial gray level dependence method (SGLDM) [54]	A hybrid method to classify the microcalcifications in mammogram. SGLDM is used for feature extraction. Feature selection is performed using GA, ACO and PSO. The selected features are then fed to a three-layer BPN hybrid with ACO and PSO for classification.
Particle Swarm Optimization, Ant Colony System, Median Filter, Bilateral Subtraction [55]	A method to automatically detect breast border and nipple position to identify the suspicious Regions in Mammograms based on Asymmetries is proposed. Image is enhanced using median filter. Then the pectoral muscle regions are removed. PSO is used to enhance the detected breast border whereas the ACS to identify the nipple position.
Genetic Algorithm, Back propagation Network, PSO, Spatial Gray Level Dependence Method	A new PSO method proposed for feature set selection and classification of micro calcification in mammograms in hybrid with GA and three-layer BPN respectively. Features are extracted

Method	Description
(SGLDM) [6]	using SGLDM.
Particle Swarm Optimization and Finite-difference frequency domain (FDFD) [56]	A technique using finite-difference frequency domain in hybrid with PSO has been proposed for the reconstruction of cell dimension in breast cancer and to find its position. It uses 2-D and 3-D breast models.
Particle Swarm Optimization and Fuzzy C means [57]	A new classification approach is presented using PSO algorithm based clustering technique, for detection of micro calcification in digital mammogram. Fuzzy C-means clustering technique is used in combination with PSO.
Particle Swarm Optimization, Back-propagation Algorithm and Multilayer feed forward networks [58]	PSO algorithm is used to optimize the adaptive neuro fuzzy model for detecting the microcalcifications in breast sonograms. Back-propagation algorithm is used to train the Multilayer feed forward networks.
Chaotic Multi Swarm Particle Swarm Optimization (CMS-PSO) [59]	A new approach for estimation of multi-dimension parameter and optimization by modifying the chaotic sequences of generic PSO algorithm.
Particle Swarm Optimization for breast mass segmentation [60]	PSO algorithm is used to improve the dynamic programming for segmenting the masses in breasts.
Automatic Seeded Region Growing and PSO [61]	A method for segmenting the breast tumor images using modified automatic seeded Region Growing based on Particle Swarm Optimized image clustering.
Permittivity estimation using Particle Swarm Optimization [62]	An algorithm is proposed to estimate the permittivity of the tissue layers for the detection of breast cancer using Particle Swarm Optimization at microwave frequency band.
Particle Swarm Optimization and k-Neural Networks [63]	A shape based used diagnosis scheme for feature selection and classification by embedding PSO with k-Neural Networks
Particle Swarm Optimization and Least-Squares Support Vector Machine(LSSVM) [64]	A morphology based heuristic scheme is proposed for model selection and classification of clustered micro calcifications using PSO and LSSVM. PSO reduces the input feature space dimension and also optimizes the hyper-parameters of classifier.
Particle Swarm Optimization and fuzzy c-mean (FCM) [65]	A hybrid algorithm for enhancing the segmented mammogram images by FCM algorithm using heuristic PSO algorithm.
Genetical Swarm Optimization Algorithm [66]	An approach to optimize the feature sets for improving the classification accuracy in digital mammograms using Genetical Swarm Optimization which is a hybrid of Genetic algorithm and Particle Swarm Optimization.
Swarm Optimization Neural Network (SONN) [76]	A hybrid approach for detection and classification of micro calcifications in mammogram images using Swarm Optimization Neural Network.
Particle Swarm Optimization, Ant Colony Optimization, Genetic algorithm(GA) and Neural Networks [67]	An improved Computer-aided Decision support system for classifying the tumor and identifying the stages of cancer using neural network in hybrid with PSO and ACO. Multi-objective genetic algorithm has been used for optimal feature extraction.
Contrast Limited Adaptive Histogram Equalization(CLAHE), Local Contrast Modification (LCM) and PSO [68]	To obtain good quality mammogram images for efficient detection of cancer by tuning the enhancement parameter of LCM-CLAHE of mammogram images using PSO.
Particle Swarm Optimization, Fuzzy Support Vector Machine (FSVM) [69]	A model proposed for tacking imbalanced classification problems in mammograms using PSO in hybrid with FSVM. PSO algorithm utilizes G-mean measure to optimize its parameters in imbalanced classification problems.
NSBPSO [70]	To achieve the trade-off between exploitation during the search process using BPSO variant with neighborhood search.
Particle swarm optimization, Job scheduling problem [71]	To tackle minimizing make span problem for jobs on unrelated parallel machines, a heuristic PSO algorithm has been proposed. It results in very accurate and outperformed existing meta heuristic methods.

TABLE IV

A survey on application of algorithms inspired by fireflies

Method	Description
Firefly for Breast cancer classification [72]	Firefly algorithm is used to improve the performance of Local linear wavelet neural network for the classification of breast cancer by optimizing the network parameters.
Firefly for Scheduling [73]	A method uses firefly algorithm to perform Job scheduling in grid computing.
Firefly for Shop scheduling problem [74]	A discrete meta heuristic firefly algorithm with local search is used for minimizing the make span in shop scheduling problems especially in permutation flow shops.

III. CONCLUSION

Several methods have been proposed to solve and optimize the difficult combinatorial optimization problems. But algorithms inspired from the natural behaviour yields special attention for its performance. This paper specifically lists some of the applications of

bio-inspired swarm intelligence based algorithms in various fields for accomplishing various tasks. This natural technique of computing provides a number of ways for solving the real world problems more efficiently and quickly with accuracy. Among them, PSO has a wide range of applicability which makes it one of the important and efficient techniques for its wide range of applications.

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