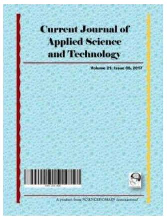

Current Journal of Applied Science and Technology

28(2): 1-9, 2018; Article no.CJAST.42200
ISSN: 2457-1024
(Past name: British Journal of Applied Science & Technology, Past ISSN: 2231-0843, NLM ID: 101664541)

Ant Colony Optimization and the Solution Proximity

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Authors' contributions

This work was carried out in collaboration between all authors. Author MSUO designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors OE and AII managed the analyses of the study. Author AII managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2018/42200
Editor(s):
(1) Dr. Ahmed Mohamed El-Waziry, Professor, King Saud University, College of Food and Agriculture Sciences, Kingdom of Saudi Arabia.
Reviewers:
(1) Vikram Puri, Duy Tan University, Vietnam.
(2) Anand Nayyar, Duy Tan University, Vietnam.
(3) Utku Kose, Suleyman Demirel University, Turkey.
Complete Peer review History: http://www.sciencedomain.org/review-history/25339

Short Research Article

Received 16th April 2018
Accepted 25th June 2018
Published 30th June 2018

ABSTRACT

Nature as designed has its complexity but the challenges posed by it gave room for several methods considered to be best fit for human survival. The role of science and other related fields have so far solved some of the challenges that may have classified humans unfit within the design frame. The survival of human in respect to problem solving varies from time to time and the method employed defined the result from the beginning. Ants and other insects are part of the design nature. Empirical studies on insects have showed complex problems resolved effortlessly with better cooperation and collaboration. This is seen from Ants structural design, building of bridges for navigation purposes, and the path routing for food as well as survival. This paper present an experiment carried out to ascertain the ant colony optimization and the solution proximity vis-à-vis solving the complexity posed by nature and humans. The experiment used two varieties of insect. A is the Ant experiment with ratio 26:8 of surviving rate and isolated rate while B is the Fly experiment with ratio 2:10 of the surviving rate and isolated rate respectively.

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Keywords: Swarm intelligence; structure; algorithm; navigation; scientist; human.

1. INTRODUCTION

Nature offers varieties of behaviour as well as the sustainable principles that guide the collective pattern of human interest. Different animals accommodated by nature and its integration in special habitats gave rise to the behavioural pattern seen today. Indeed, nature has its role to play in the manner and pattern of animal's integration, polarity, interactions and the diversify structure of proliferation.

Ants Colony such as ton of termites, bees, congregates of birds to the ever present fishes, wolves, group of animals, massive movement of human, different aquatic animals, man made species and even plants exhibit special structural dynamics or patterns. These structures as articulated above do not exist in vacuum, they represent special gift by God to humans and critical analysis could mean better life for the human development. Scientists observed that self-organized behaviour is actually the solution to ranges of both biological problem and social problem in the 21st century [1,2]. Field such as sociology, computer graphics, biology, botany, zoology, social network, artificial intelligence, network and graph theory, automata as well as social sciences courses (economics, accounting etc) are areas where critical studies have emerged in ant colony. Different models have also been proposed by scientists in the course of research, the model idea is to understand the behavioural pattern of animal collections and among the pattern is the insect with over a million species. Indeed the classification of the insect specie is half of organism living on earth. From empirical view, insects exhibit a collection of behaviours quite not the same with other animals and varies from Phase transition, Affirmative Phototaxis, Aggregation, Mass migration, escape route, response, resilience, adaptation [3].

Insect have several collective usefulness in areas such as modelling behaviour. In a related work as captured by the author below it is admitted that the suggestion by some literatures on biological research on model based self-organization could be the answer to complex behaviours as seen in the interactions among insects [4]. This comprehensive idea has exponentially increased the potentials of scientist into Ant colony and has brought about new era in the ant colony studies. It is observed that the social insect settlement and its method of cohabiting and intelligence are becoming key interest in research community [5,6,7,8]. In recent times, several fields such as Ant Routing, Algorithm for Ant Colony Optimization Ant Shortest Path Navigation, Ant Routing and Colony Optimization have emerged due to this phenomenon [9,4,10,11,12,13,14,15]. Swarms Intelligence is another new area currently calling for research but the colonization of its behavioural pattern has been an age past phenomenon. Researchers and scientists have come to realize its importance in changing certain behaviour with the sole purpose of championing long lasting solutions to everyday activity. However, this has not always been and the reason is attributed to recent modelling techniques for multi-agent base systems which is a relatively new field in networking and AI. The aim to transfer the model into real behaviour of flying insect has struggle a bit [16,17].

Fig. 1. Pictorial view of Ant colony bridges [18]

Insects have some dynamic attributes and these attributes could be the definition to the task complexity of human. A study into the uniqueness of nature and its algorithm as demonstrated by ant colony is an insight into the creation of social engineering model that could resolve human complex task. Swam intelligence (SI) is seen as a new interest in research community and it is potentially endow with different algorithms capable of enhancing the method of solution to task complexity. The future has more to exploits in swarm intelligence, some fields as stated below uses swarm intelligence approach in creating suitable computing and sustainable platform for human interaction. Human can learn variety of things from the behavioural pattern and method of ant solution proximity. Furthermore, it is difficult to see a single ant in an isolated route and every movement by ant is an indication for better collaboration for food and survival [19].

2. RELATED LITERATURES

Ant colony optimization examine the pattern to which problems are resolved effortlessly among insects and applied to the problem facing the computing world vis-à-vis creating model that best define the state of things. Hence, Ant colony optimization could be seen as structure where behaviours of agents cohabiting within domain are seen to have special patterns. These patterns have found usefulness in domain networking where problems are resolved from non centralized state. This coherent and functional attributes have led to problem solving from the bottom-top approach rather than top-bottom within systems thereby creating efficacy and functionality of a system structure organization. The act of performing task effectively by group with small set of rules for individual behaviour is same as the role in ant colony [20]. Swarm Intelligence could be seen as using non intelligence machine to create a scenario that require other agents' response in more positive call. In networking, Swarm Intelligence has dominated over 60% of its activities unknowingly, several responses have been seen from an environment directly or indirectly by the response of the responder, even in homes where rules are set by one and thereafter reflecting the full inhabitant of such home is a principal of Swarms Intelligence (AI) in demonstration.

Swarms Intelligence as a new aspect in modern day scientific studies has gone beyond method of self-organization of insect only. Many scientists see it as a method to solving complex and non complex problem in computing and such problems are AI and natural problems. Researchers have unveiled in recent times new model from the behavioural pattern of animals to explaining social insect self-organization vis-à-vis the human method. According to research, it has been established that algorithms from these models to solving difficult computational problems have been proposed and this could be seen from the ant colony optimization that exploit discrete optimization problems [21]. Another interesting part of these models is the particle swarm optimizations which do not only deal with optimization rather with endless (continuous) optimization problems, swarms robotics centre its operational principle on a pool of autonomous robot with like minds. There are many beautiful things about social insect colony and more profound is the fact that there is no dependency and this could be view from the ant navigation of complex route by building structural dynamics like chains, bridge, nests, and route. The non dependency is the strength of ant colony interactions that solves complex task effortlessly. A social insects have some fundamentals and a well structured characteristics which makes them perform tasks effortlessly and these include the following [22].

a Flexibility
b Robustness
c Self-Organization

Different areas are currently being researched on in Swarm Intelligence. Research has shown that Automata theory and Telecommunication networks in recent times have used Swarm Intelligence. The research into telecommunication network (Computing) is known as ant-based routing as establish by research and has since witnessed numbers of disparities [15]. The probabilistic routing table is a practical example of ant-based routing and can re-enforce the reversed version of ant route [14]. Indeed other areas such as forwarding and reverse direction in re-enforcing rout have also witnessed different approach in research community. The back re-enforcement requires symmetric network that could bridge the direction. Forward re-enforcement fast track the rewarding of route even when it is yet to be ascertained. Following the study into swarm intelligence (SI) as demonstrated in some literatures, new technology like smart phones (mobile) merchandise have enough to gain if redeploy into full functionality among production companies [23].

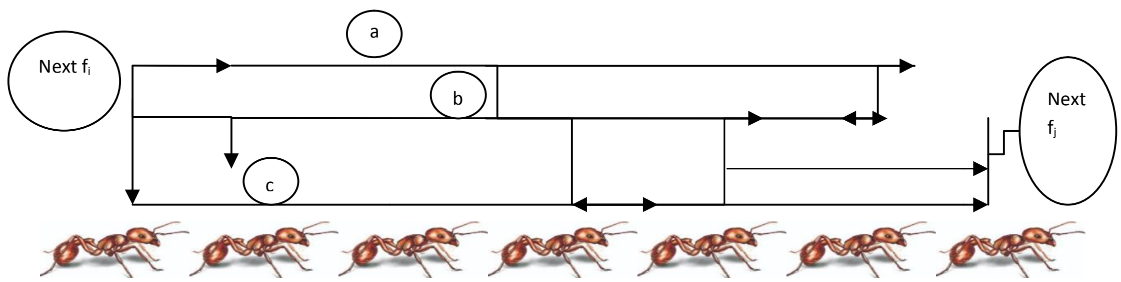

Fig. 2. Ants next swap

Stochastic diffusion search (SDS) is another Swarm Intelligence algorithm being used in the provision of a model for transmission of infrastructure location in wireless network (packing and set covering). SDS is a model for identification of the best possible solutions for large problem scenarios. The ant-based routing is endless and its usage cuts across Airline and others so far examined. The method of distinguishing aircraft arrival at the gate terminal has found its route in SI. The demonstration of this was the Southwest Airline program that allows each pilot navigate around airport terminal that best suit their arrival which is similar to ant in search of shortest path [24,25].

3. ANT COLONY OPTIMAZATION

Ant colony optimization (ACO) is an act of route complexity maximization as well as search accuracy [26,27,28]. Ant function search for food using shortest path approach, the quest for search of food or survival is a direct exercise of ant movement structure from one region to another and this actualization has been investigated to be an ant natural embedded chemical [29,30,31]. The chemical enables other ants to navigate the same part used by the first ant who by virtue of searching for food or survival used the shortest path. The Pheromones is an attractive chemical that enable other ants have full knowledge of the shortest route to follow. The amount of pheromones deposited by the first ant gives clarity and the viability of the route which in turn enable other ants discover the route to survival.

The ant migrates from one region to another in a synergized structure, the structure as synergized by the movement represents varieties of solutions to human structural problems as well as other areas such as the unity and oneness currently unavailable in the day to day problem solving of humans [32,33,34]. The Fig. 1 represents the movement of ant from next f_i to next f_j with three navigating options.

4. ANT COLONY OPTIMIZATION MODEL

The ACO model uses two updating approaches. Firstly, the local trail updating using the attributes of pheromones modification. The method works in procedural steps and at each point of city navigation the modification of trail occurs making it a localized movement update. Secondly, the end product of the local trail update is to enable all ants using the path have smooth passage of route based on the pheromones trail which attracts all other ants and when this is done, the classified shortest path by the discovering ant is identified, modified and increase the amount of pheromones chemical that equal the path so as other ant rout the path as signed by the discovering ant [35,33]. Authors of different sides have proposed different schemes. Research had it that there is currently a global development of computing hardware and software in sustainable approached that hence make the modern gadget friendly in it navigation and usage [36]. However, the end spectrum of ACO is to use the best possible method as captured above in resolving complex task.

5. THE PROBALISTIC TRANSITION RULE

At every given point in time ants move from one region to another leaving pheromones at each path of the navigation edge [35,33]. The movement could be f_i to f_j depending on the search. The movement of ant K_{th} from edge f_i to city f_j is defined by the probalistic transition rule below

$$T_{ij} = \sum_{k=1*1}^{n} \sigma T_{ij} + T_{ij} \ (1–p) \quad (1)$$

Fig. 3. Lessons from ant colonies [19]

The pheromone percentage excreted and evaporated is represented by p, the number of ants is represented by n, and the change Pheromone movement between cities is denoted by $\boldsymbol{\sigma}T_{ij}$ as well as ($_{i\ and\ j}$) using the constant factor of 1*1

$$N(_S{}^p) = r \quad (2)$$

The r defines the cities arrangement in a sequential order of i and j

$$\text{Let city be} = g \quad (3)$$

g is the tour edges

$$P_{ij} = \frac{(T\ (_{ij})^{\alpha} * n(_{ij})^{\beta})}{\sum T\ (_{i1})^{\alpha} \sum n(_{i1})^{\beta}} \quad \text{if } g\ \varepsilon\ r \quad (4)$$

$g_{ij\ =\ r}$

T_{ij} is the Pheromone

n_{il} classify the proportional distance and the navigating information of edge f_i to $f_{j,}$ hence the T_{ij} and n_{ij} represents the discovering trail ant in a loop.

$$d_{ij} = d_{ij} * t_{ij} \quad (5)$$

$$n_{ij} = i/d_{ij} \quad (6)$$

The distance between f_i and f_j is shown by (5) and (6)

$$T_{ij} \leftarrow (I\text{-}P)_{ij},\ \vee(_{ij}) \quad (7)$$

Recall that the T_{ij} is the pheromone and P the evaporated pheromone

$$T_{ij}\ (t)=T_{ij}\ (I\text{-}p),\ \ p.\ To + (t\text{-}p) \quad (8)$$

p is the evaporated pheromone while T_0 defines the starting value of the pheromone chain demonstrated by the tour as shown in equation (9) examined and classified calculation

$$(n^*L_m)^{-1} = T_o \quad (9)$$

$$T_{ij}\ = T_{ij}\ (1\text{-}P),\ P/L + (t\text{-}1) \quad (10)$$

The length of each tour known to be more attractive tour is represented by L showed in equation (10)

6. ANT COLONY AND SOLUTION PROXIMITY WITH TRAVELLING SALESMAN PROBEM (TSP)

The ant colony transition rule is the base end route to effortlessly approach employed by ant in ensuring the survival of other ants. The solution proximity (SP) is a graphical representation of the natural movement of ants from point A to point B. An empirical study carried out on the behavioural pattern of ants shows clear dimension to the natural pattern of humans demonstrated periodically. The experiment conducted was to show how best an ant or ants can survival two critical regions void of the ants natural habitat.

Travelling Salesman Problem (TSP) describes the path routed in different routes with concentration on the shortest route to the destination of journeying with starting point A and destination point Z. The TSP involves the process of different cities combination (entity) logically resolved via mathematical or statistical method of optimization. History dated back revealed that Hassler Whiteney an American first used it in his mathematical formulation. According to study, TSP is an N cities given when a journey is said to be made from a home (starting point) to all the cities once in a given graph then return back to the destination of the starting point with order of tour of destination travelled kept in it shortest (minimum) path [37]. Each edge of the finite graph of the city is assigned a weight with key interest in the vertices navigation between cities.

Ant and flies are both insect with distinctive attributes and characteristics for solution proximity. The Figure below represents experiment conducted in ascertaining the survival rate and quest for life between two kinds of insects.

Fig. 4 is a classification of the experimental insect variable against the isolated insect put into empirical text. The text is to evaluate the strength and the algorithm pattern for navigation in a critical region considered to be far from the traditional or natural habitat navigated by the evaporation of the pheromone.

6.1 Experiment (B)

This involves the numbers of fliers stated in the Table 1. 12 fliers were place placed and covered with plastic bowl with tiny hole wide enough for ventilation and escape and this was observed for some about three hours. The experiment showed that two out of the number of fliers were able to escape through the escape rout provided while ten waited for the bowl to be opened.

6.2 Experiment (A)

This experiment show clear difference from experiment B. the same number of ants captured in Table 1 placed on the same spot of the fly using the same bow with tiny space that could act as escape route. The ants were placed on the number of house used in the observation of fly and at the end of the experiment twenty (26) survival using two distinct methods.

Table 1. Experimenting the survival ratio of ants and flies

Insects classification	Number of ants and flies experimented	Isolated insect	Survival insect	Isolated and survival Ratio	%
A	34.000	8.000	26.000	26.000:8.000	76.5 Survival 23.6 Isolated
B	12.000	10.000	2.000	2.000:10.000	83.4 Survival 16.7

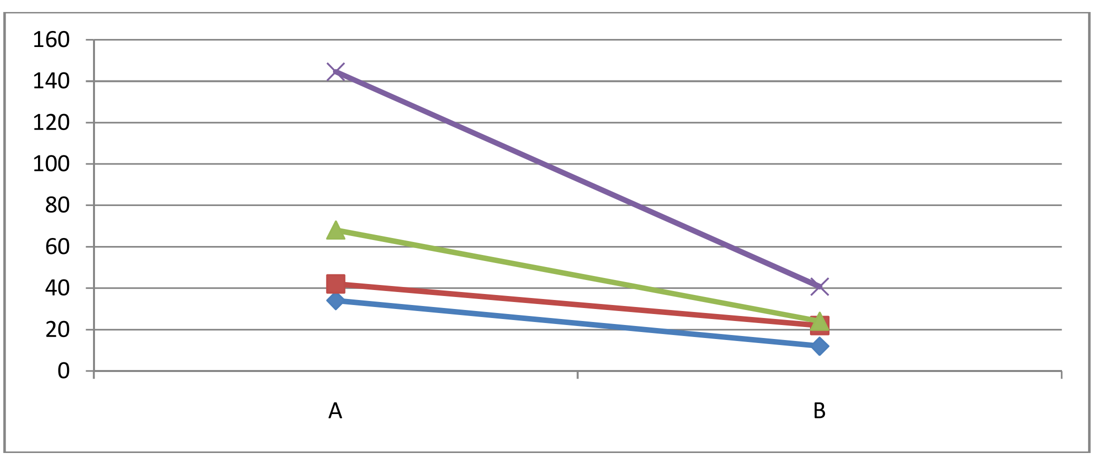

Fig. 4. Representation of the isolated, survival insects and the experimental number

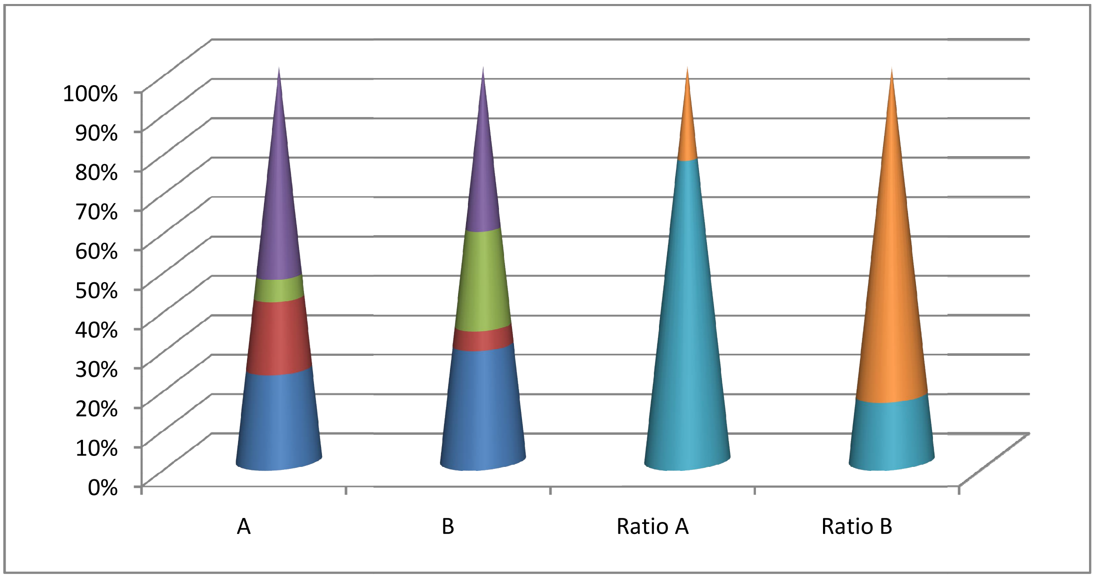

Fig. 5. Experimental Scale of A and B

Firstly, the method adopted by the ant was to use the tiny hole provided for ventilation as escape route but this was far less than the average number of the total number of ants. The second method was a clear definition for solution proximity. Rather than the ant using the tiny hole, a search for different navigation rout was observed. Majority of the number of ant used a different escaping rout as classified in the Table 1 above. The solution proximity is a method that best define the survival quest of ants. The critical state of the ant defines the survival techniques.

A key observation is the fact that the ant demonstrated some intelligence in its survival which in this paper the author classified as "solution proximity". The navigation technique is a clear difference in the navigation process of the experimental performance of A.

7. CONCLUSION

Ant colony optimization and the solution proximity is an intelligent approach to problem solving and survival. Insect of various capacities demonstrates self will in responding to different challenges posed by nature. Nature is complex and anything provided by nature requires systemic steps. The bridges, structures, cohabiting and systemic navigation for survival demonstrated by insects (ants) on a daily basis should not be in vacuum. The study into these phenomenal patterns of bridges, structures, survival etc has become the needed solution required by human in resolving the complexities faced by the endless problem nature and human have caused. Researches are currently on in some critical areas of sciences, social sciences, engineering, medicine, and computer science (automata theory, theoretical computation and artificial intelligence). The aim of the research is to see how predefined complex tasks can be solved with ant colony optimization (ACO) and Solution proximity.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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ISSN: 2248-9622.
Available:www.ijera.com

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history/25339