

ANT COLONY OPTIMIZATION AND THE SOLUTION PROXIMITY

Abstract:

Nature as designed has its complexities but the challenges posed by it give room for several methods considered to be best fit for human survival. The role of science and other related fields have also helped to solve 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 thus far shows 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

Keywords: Swarm Intelligence, Structure, Algorithm, Navigation, Scientist, Human

I. 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 integration, polarity, interactions and the diversified structure of proliferation.



32 Figure 1 Ant building bridge algorithm [36]

33 Scientifically, Ants Colony [26, 28], such as ton of termites, bees, congregates of birds to
 34 ever present fishes, wolves, group of animals, massive movement of human, different aquatic
 35 animals, man made species and even plants exhibit special structural dynamics or patterns.
 36 These structures as articulated do not exist in vacuum, they represent special gift by God to
 37 humans and critical analysis could mean better life for the developmental shift for humans.
 38 Scientists observed that self-organized behaviour is actually the solution to ranges of both
 39 biological problems and social problems in the 21st century. Studies and published literatures
 40 in sociology, computer graphics, biology, botany, zoology, social network, artificial
 41 intelligence, network and graph theory, automata as well as some fields in the social sciences
 42 (economics, accounting etc) are areas where critical studies has emerged in ant colony.
 43 Different models have also been proposed by scientists in the course of research to
 44 understanding the behavioural patterns of animal collections and among these patterns is the
 45 insect with over a million species. Indeed the classification of the insect species is half of
 46 organism living on earth. From empirical view, insects exhibit a collection of behaviours
 47 quite not the same with other animals and varies from Phase transition, Affirmative
 48 Phototaxis, Aggregation, Mass migration, escape route and response, resilience, adaptation,
 49 etc. [1]

50 According to [2] Insect have several collective usefulness in areas such as modelling
 51 behaviours, the author admits that the suggestion that biological research on model based
 52 self-organization could explain clearly the complex behaviours from the interactions among
 53 insects. This comprehensive idea has exponentially increased the potentials and has brought
 54 about a new era in the ant colony studies where social insect settlement and its method of
 55 cohabiting and intelligence are being carefully observed. In recent times several fields such as
 56 Ant Routing, Algorithm for Ant Colony Optimization [16, 17, 18, 19], Ant shortest path
 57 Navigation[24], Ant Routing and Colony Optimization [20, 21, 22, 23] etc have emerged due
 58 to this phenomenon [2, 9, 10,]. Swarms Intelligence is another new area currently calling for
 59 research but the colonization of its behavioural patterns has been an age past phenomenon.
 60 Researchers and scientists have come to realize its importance in changing certain behaviours
 61 with the sole purpose of championing long lasting solutions to everyday activity but this has
 62 not always been because recent modelling techniques for multi-agent base systems which is a
 63 relatively new field in networking and AI field to transfer this model into real behaviour of
 64 flying insect has struggled a bit [25, 27].

65 II. RELATED LITERATURES

66 Ant colony optimization examine the pattern to which problems are resolved effortlessly
 67 among insects and applied to the problem facing the computing world vis-à-vis creating
 68 model that best define the states. Hence, Ant colony optimization could be seen as structure
 69 where behaviours of agents cohabiting within domain are seen to have special patterns. These
 70 patterns have found usefulness in domain networking where problems are resolved from non
 71 centralized state. This coherent and functional attributes have led to problem solving with the
 72 down-top approach rather than top-down within system thereby creating efficacy and
 73 functionality of a structural organization. A study by [3] unveils the act of performing tasks
 74 effectively by group with small set of rules for individual behaviour is same as the role
 75 played by ant colony. Swarm Intelligence could be seen as using non intelligence machine to
 76 create a scenario that requires other agents' response in more positive notes. In networking,
 77 Swarm Intelligence has dominated over 60% of its activities unknowingly, several responses
 78 have been seen from an environment directly or indirectly by the response of the responder,

79 even in homes where rules are set by one and thereafter reflecting the full inhabitant of such
80 home is a principal of Swarms Intelligence (AI) in demonstration

81 Swarms Intelligence as a new aspect in modern day scientific studies has gone beyond
82 method of self-organization of insect only. Many scientists see it as a method to solving
83 complex and non complex problem in computing and such problems are AI and natural
84 endowment. Many researches have unveiled in recent times a new model from the
85 behavioural pattern of animals to explaining social insect self-organization vis-à-vis the
86 human method. According to [4] in a research established that algorithms from these models
87 to solving difficult computational problems have been proposed and this could be seen from
88 the ant colony optimization that exploit discrete optimization problems. Another interesting
89 part of these models is the particle swarm optimizations which do not only deal with
90 optimization rather with endless(continuous) optimization problems, swarms robotics centre
91 its operational principle on a pool of autonomous robot with like minds. There are many
92 beautiful things about social insect colony and more profound is the fact that there is no
93 dependency and this could be viewed from the ant navigation of complex route by building
94 structural dynamics like chains, bridge, nests, and route. The non dependency is the strength
95 of ant colony interactions that solves complex task effortlessly. As published by [5] social
96 insects have some fundamental and well structured characteristics which makes them perform
97 tasks effortlessly shape and these include the following

- 98 a Flexibility
- 99 b Robustness
- 100 c Self-Organization

101 Different areas are currently being researched on in Swarm Intelligence. Research has shown
102 that Automata theory and Telecommunication networks of recent have used Swarm
103 Intelligence. The research into telecommunication network (Computing) is known as ant-
104 based routing as establish by [23] and has since witnessed numbers of disparities. The
105 probabilistic routing table is a practical example of ant-based routing as established by [22]
106 and can re-enforce the reversed version of ant route. Indeed other areas such as forwarding
107 and reverse direction in re-forcing rout have also witnessed different approach in research
108 community. The back re-enforcement requires symmetric network that could bridge the
109 direction. Forward re-enforcement fast track the rewarding of rout even when it is yet to be
110 ascertained. With swarm intelligence, as demonstrated in a literature by [6] new technology
111 like smart phones (mobile) world have enough to gain if fully redeployed into full
112 functionality [6].

113 According to [7], stochastic diffusion search (SDS) is another Swarm Intelligence algorithm
114 being used in the provision of amodel for transmission of infrastructure location in wireless
115 network (packing and set covering). SDS is a model for identification of the best possible
116 solutions for large problem scenarios. The ant-based routing is endless and its usage cuts
117 across Airline and others so far examined. The method of distinguishing aircraft arrival at the
118 gate terminal has found its route in SI. The demonstration of this was the Southwest Airline
119 program that allows each pilot navigate around airport terminal that best suit their arrival
120 which is similar to ant in search of shortest path [8].

III. ANT COLONY OPTIMAZATION

Ant colony optimization (ACO) is an act of rout complexity maximization as well as search accuracy [15, 32, 33]. 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

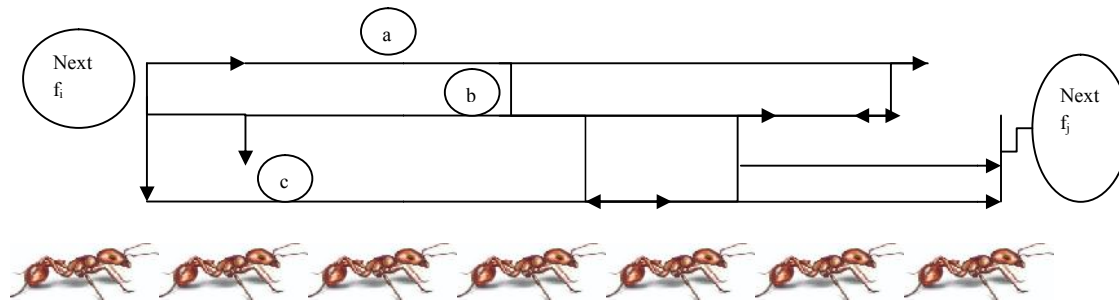


Figure 2 Ants Next Swap

The ant migrates from one region to another in a synergized structure[14], 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 [12, 13]. The figure1 represents the movement of ant from next f_i to next f_j with three navigating options.

IV. 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 [11, 12]

V. 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 or edge [11, 12]. 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



Figure 3, Lessons from Ant colonies [35]

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

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 σT_{ij} as well as $(i \text{ and } j)$ 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

$$P_{ij} = \frac{(T_{ij})^\alpha * n(i)^\beta}{\sum (T_{ij})^\alpha \sum n(i)^\beta} \quad \text{if } g \in r \quad (4)$$

$$g_{ij} = r$$

T_{ij} is the Pheromone

n_{ij} 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)

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

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

$$T_{ij}(t) = T_{ij}(1-p), p. T_o + (t-p) \quad (8)$$

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

$$(n * L_m)^{-1} = T_0 \quad (9)$$

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

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

VI. ANT COLONY AND SOLUTION PROXIMITY WITH TRAVELLING SALESMAN PROBLEM (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 Whitney an American first used it in his mathematical formulation. According to [34] 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. Each edge of the finite graph of the city is assigned a weight with key interest in the vertices navigation between cities.

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

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.

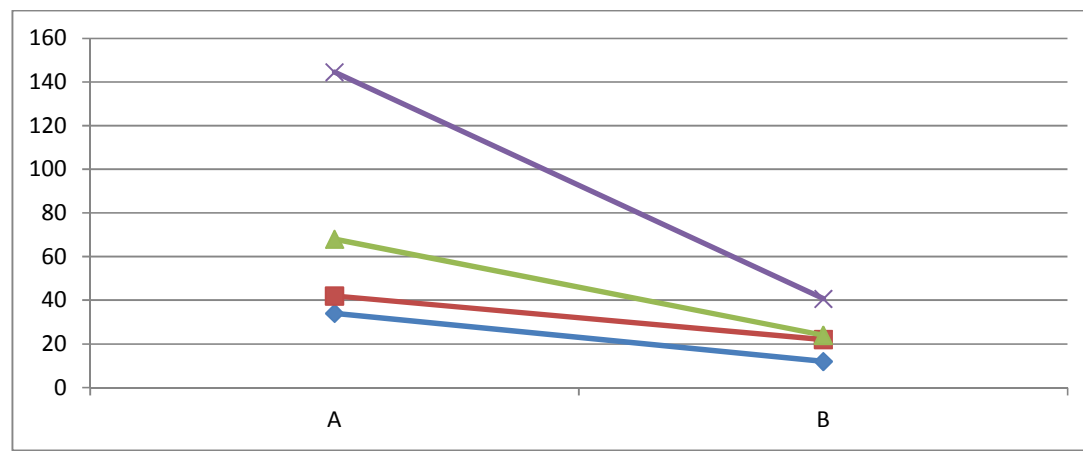


Figure 4 Representation of the isolated, survival insects and the experimental number

Figure 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.

Experiment (B)

This involves the numbers of fliers stated in the Table 1 above. 12 fliers were 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 route provided while ten waited for the bowl to be opened.

Experiment (A)

This experiment show clear difference from experiment B. the same number of ants captured in Table 1 above were placed on the same spot of the fly using the same bowl 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.

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 route was observed. Majority of the number of ant used a different escaping route 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.

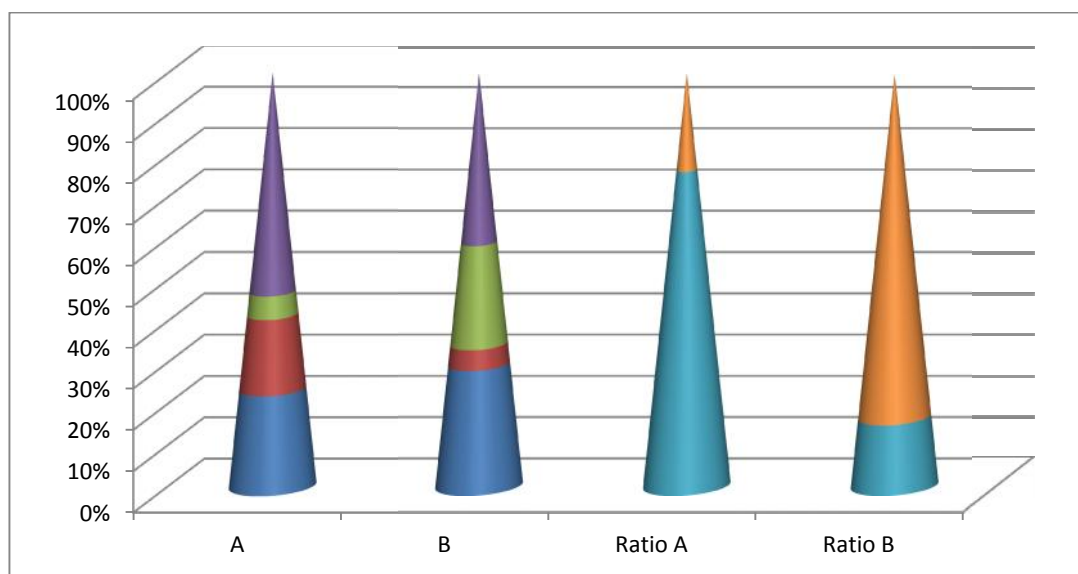


Figure 5 Experimental Scale of A and B

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, 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. Different fields such as science, social science, engineering, Medicine, and core field such as computer science, automata theory, theoretical computation, artificial intelligence should focus on how simple and complex tasks are resolved by ant solution proximity with the goal of translating it into real and tangible solution in the complexity of human day to day activities

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