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A SWARM INTELLIGENCE OPTIMIZATION APPROACH FOR PROBABILISTIC EMERGENT ROUTING

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Abstract: The world around us is becoming increasingly complex every day and changes dynamically. The problems that we face require adaptive and scalable systems that can offer solutions with ever-rising level of autonomy. Traditional approaches are becoming obsolete because they were designed for a simpler world. Therefore, any advancement in understanding and solving of complex problems can have an impact on the entire set of disciplines in engineering, biology, sociology, etc. Swarm Intelligence is a problem-solving behavior that occurs as a result of a multiplicity of interactions between independent components that make up the entire system. The algorithms inspired by the cooperative behavior in nature, as in colonies of social insects, rely on artificial swarms of agents and were initially applied to solve the combinatorial optimization problems. Swarm intelligence comes from the biological study of social insect and insight about how they manage to solve complex problems in their daily lives. Research field as swarm systems are examples of behavior based systems. The most common form of communication among social insects is the use of pheromones. Pheromones are chemical signals sent out from one individual to trigger a reaction behavior on the receiving individuals of the same species. The proposed approach can be useful in traveling salesman problem also in optimized way of path finding.

Keywords: Swarm Intelligence, Hive, Piping, Quorum.

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INTRODUCTION

Swarm Intelligence approaches are more promising for Mobile Ad hoc Networks (MANET) and wireless sensor networks due to the following prominent aspects [4],

i. Locality of interactions

ii. Availability of multiple paths

iii. Self-organizing behaviors

iv. Scalable performance robustness to failures

v. Easiness of design and tuning

The subtype of networks that is self-configured, infrastructure less, network of mobile devices connected by wireless links, is named Mobile Ad hoc Network (MANET). MANET can also be defined as, a collection of mobile wireless nodes that intercommunicate on share wireless channels.

Mobile Ad-Hoc Networks (MANETs) are formed by a collection of mobile nodes, each equipped with wireless communication capabilities, without relying on any fixed infrastructure or centralized administration. In order to maintain network connectivity, each node may act as an

ad hoc router, forwarding data packets for other mobile nodes that may not be within direct transmission range of each other. This enables fast deployment of high-bandwidth infrastructure-independent networks.

Due to unique characteristics of mobile ad hoc networks, nontrivial challenges could be posed to security design, such as open peer-to-peer network architecture, shared wireless medium, stringent resource constraints and highly dynamic network topology. The use of Swarm Intelligence (SI) in solving Traveling Salesman Problem (TSP) where a salesman who wants to find the shortest possible trip through a set of cities on his tour of duty, visiting every node once. Also reducing traffic congestion is quite urgent because the amount of money lost due to congestion in traffic networks.

Nature has always inspired researchers. By simple observing we can sometimes notice the patterns, the set of rules that make seemingly chaotic processes logical. How do we think and how do we memorize? Why is evolution so important for the survival of species? How do the social insects know how to follow the path to a source of food without the global knowledge? These questions are partially answered by computational intelligence (CI). Traditional optimization search methods may be classified into two distinct groups: direct-search and gradient-based search methods. Swarm intelligence systems are candidates to meet the requirements of complex path and fault management problems in today's networks.

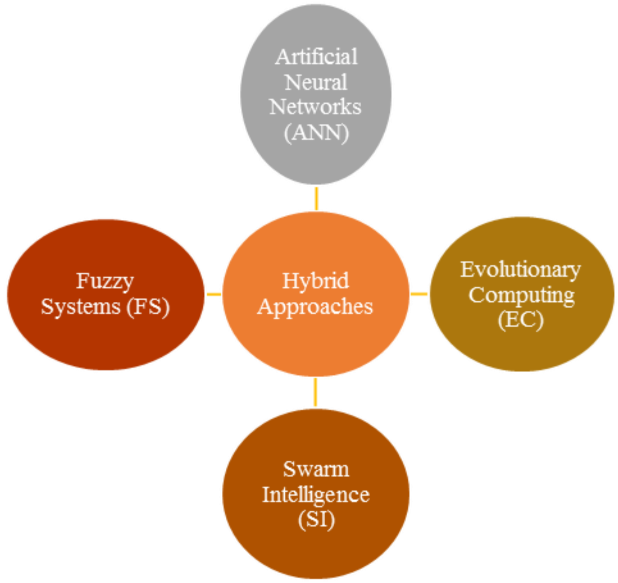

Figure. 1: General Optimization Approaches

Bee colony algorithm is currently used in many areas to solve combinatorial optimization problems. In their algorithm, servers and HTTP request queues in an Internet server colony are modeled as foraging bees and flower patches respectively. This section describes the existing work done on this area of research. Nakrani and Tovey (2004) first proposed the use of a honey bee algorithm for dynamic allocation of Internet servers. The experimental results show that the algorithm performs reasonably well in the dynamic allocation problem. Social insect colonies can be considered as dynamical system gathering information from environment and adjusting its behaviour in accordance to it. While gathering information.

2. LITERATURE REVIEW:

Joshua Kirby et al.[1] introduced a novel swarming interpolation framework and validated its effectiveness on static fields. Proposed framework can be used to control autonomous mobile sensors into flexible spatial arrangements in order to interpolate values of a field in an unknown region. Sorin Ilie and Costin Badica [2] proposed a framework based on Ant Colony Optimization on a Distributed Architecture (ACODA), for implementation of SI algorithms aimed at solving complex graph search problems. In [3] Jiraporn Kiatwuthiamorn and Arit Thammano proposed an optimization technique based on the ant colonies. Sifat Momen[4] investigates that effects of biasness in brood caring on the performance of the colony, it is observed that a little biasness in brood caring results in a statistically improvement in the performance of the colony. Omid Nezami et al. [5] found the appropriate regions of search space by introducing new artificial particles based on historical information.

Imane Fahmy et al. [6] proposed the The Predictive Energy Efficient Bee-inspired Routing algorithm for Mobile Ad-hoc Networks (MANETs). The proposed algorithm was to find the optimal path among a number of potential paths between a certain source-destination pair. Patrick Benavidez et al. [7] investigated the problems related to swarm robots to coordinate their actions to accomplish a given task in multi domain systems and developed protocol which is flexible enough to handle different types of data such as GPS, image, and control commands. John Baras et al. [8] proposed a set of routing algorithms for MANETs based on the swarm intelligence paradigm. It observes that end-to-end delay for swarm based routing is low compared to AODV. However, the good put for these algorithms is lower than for AODV in scenarios with high mobility [10].

3. Dynamic Diversity Enhancement Particle Swarm Optimization algorithm

Animal behavior has always been a source of amazement to mankind. In many areas the abilities of the animals surpasses the abilities of us humans, but with the use of technology we have been able to best the animals in more and more areas. By studying the behavior of animals we have been able to find many interesting solutions animals apply to the problems in their environment. These solutions have inspired many people to think of problems in new ways, sometimes leading to new solutions, often with great results. But few things are more impressive than the way some creatures organize themselves in larger groups: birds, fishes and ants; flocks, shoals and swarms. If we can understand the mechanism of how these organizations emerge, we might be able to use the same mechanics to achieve what we have not achieved before.

The three rules formulated are still the basis of modern flocking,

1. **Cohesion**: Steer to move toward the average position of local flockmates. Cohesion is the rule that keeps the flock together, without it there would not be any flocking at all.

2. **Separation**: Steer to avoid crowding local flockmates.[3] If a flocking behaviour is to be convincing it must also avoid collisions between the boids. This rule attempts steer the boid away from possible collisions.

3. **Alignment:** steer towards the average heading of local flockmates. This rule tries to make the boids mimic each others course and speed. If this rule was not used the boids would bounce around a lot and not form the beautiful flocking patterns that can be seen in real flocks.

3.1 Particle swarm optimization

Particle Swarm Optimization or PSO is a population based evolutionary algorithm developed by Eberhart and Kennedy in 1995, inspired from social behavior of natural species such as bird flocking or fish schooling. Each particle represents a point of multidimensional search space or a solution of the multidimensional problem that flies through a search space, denoted by Xi = (xi1, xi2,...,xid ,..., xiD) for a D-dimensional problem, and looking for a globally optimal solution. So each member of the swarm adjusts its position in the search space from time to time according to the flying experience of its own and of its neighbors (or colleagues). In PSO, best position that the particle i meets in previous generations is denoted by Pi = (pi1, pi2,..., pid ,..., piD), and the best one among all the particles in the swarm is represented as Pg = (pg1, pg2,..., pgd ,..., pgD). The two basic equations of PSO which implement flying of particles are the velocity equation and the position one as the Equation (1).

$$
\begin{aligned}
V_{id} &= \omega * V_{id} + c_1 r_1 (p_{id} - x_{id}) + c_2 r_2 (p_{gd} - x_{id}) \\
X_{id} &= X_{id} + V_{id}
\end{aligned}
\qquad (1)
$$

Where Vi in the first equation is the velocity of Particle i that represented as Vi = (vi1, vi2,..., vid ,..., viD). The First part of the equation is the inertia of the previous velocity, w is predefined by the user and the second part represents the personal thinking of the particle. The third part is the social component. In this equation c1 and c2 are acceleration constants. They represent the weighting of the stochastic acceleration terms that pull each particle toward personal best and global best positions. The constants r1, r2 are the uniformly generated random numbers in the range of [0 , 1]. Velocity clamp is clamped to a maximum magnitude (Vmax) was firstly used to adjust the ability between exploration and exploitation [4, 23]. However, velocity clamp only makes algorithm les like to diverge, it cannot help algorithm "jump out" a local optimum or refine the candidate solution. In each iteration a new velocity value for each particle is calculated based on its current velocity, the distance from the local best position, and the global best position. The new velocity value is then used to calculate the next position of the particle in the search space according to Equation (1). This process is then iterated a number of times or until a certain condition occurs.

4. ANT SYSTEM ALGORITHM:

Ant Colony Optimization (ACO) is a swarm-based metaheuristic which models the foraging behavior of ant colonies in nature the ants through collaboration can solve complex problems such as finding the shortest path to a food source. This feature can be used to solve the engineering problems that require this kind of optimization. When traversing from one node to another, ants leave pheromone trails on the edges connecting the nodes. The pheromone trails attract other ants that lay more pheromone, which consequently leads to pheromone trail accumulation.

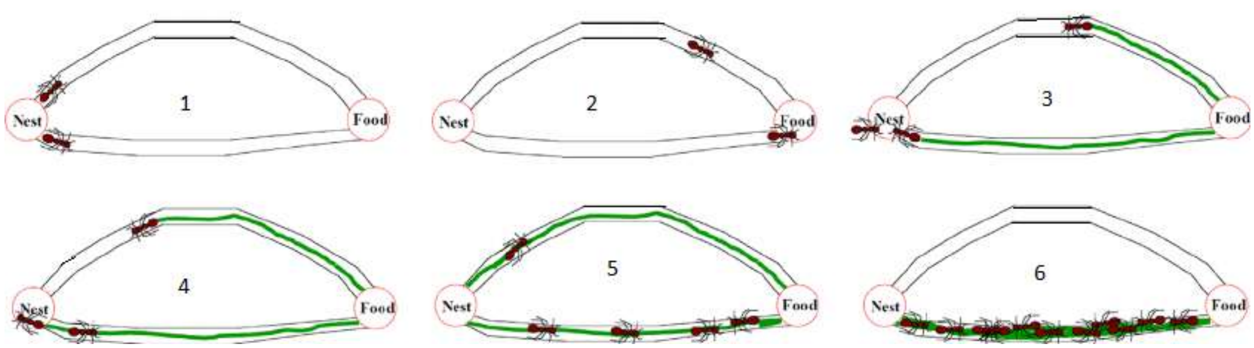

Figure 2: Ants Bridge Experiment

Negative feedback is applied through pheromone evaporation that, importantly, restrains the ants from taking the same route and allows continuous search for better solutions.

5. Honey Bee Swarms Intelligence:

Honey bee dancing is one of the most intriguing behaviors in social insects. It is a form of direct communication that worker bees use to recruit other bees in the swarm to follow them to the resource site. When a bee returns to the hive with a load of nectar that is sufficiently nutritious to guarantee return to the source, she performs a dance to share the information about the location of the food source with other bees.

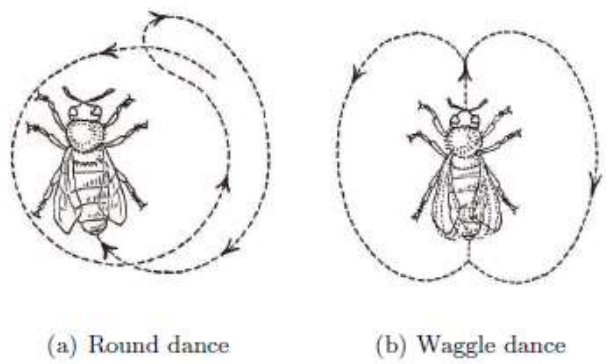

Figure 3: Honey bee dancing language

Dance patterns may contain two items of information, namely distance and direction of the food source. If a food source is located close to the hive (less than 50 m) the bee performs a round dance but if the food source is at a greater distance (more than 150 m) the bee performs a "waggle dance".

6. SIMULATION ENVIRONMENT:

The ANT-Lines model shows the swarm intelligence of ANT colonies. A swarm of tens of thousands can accurately pick the best solution available among dozens of potential choices through self-organizing behavior. The behavior of ants following a leader towards a food source, the leader ant moves towards the food along a random path; after a small delay, the second ant in the line follows the leader by heading directly towards where the leader is located. Each subsequent ant follows the ant ahead of it in the same manner.

Table 1: Simulator Parameters

Simulator Environment	**NetLogo-6.0.2**
Leader Wiggle Angle	2 Degrees
Start Delay	2 Sec
Number of Ants	[10,20,30,40,50]
Leader Heading	Random

Plots: Even though the leader may take a very circuitous path towards the food, the ant trail, surprisingly, adopts a smooth shape. While it is not yet clear if this model is a biologically accurate model of ant behavior, it is an interesting mathematical exploration of the emergent behavior of a series of agents following each other serially.

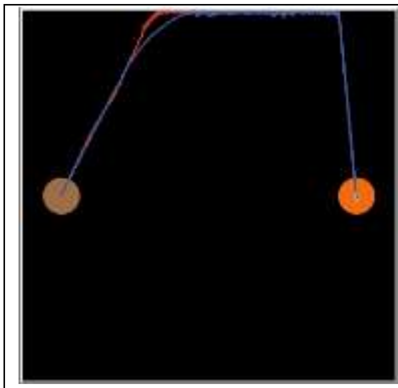

Figure 4: NANT-10

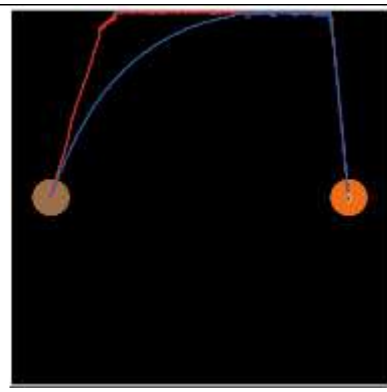

Figure 5: NANT-20

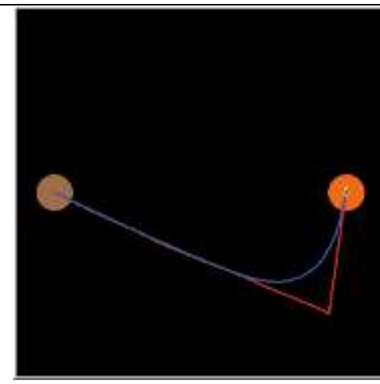

Figure 6: NANT-30

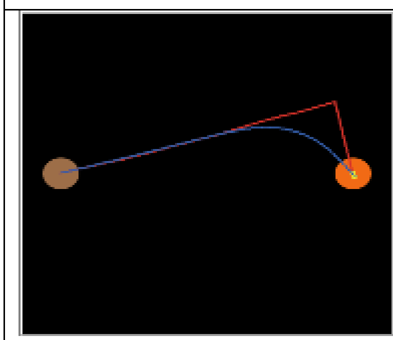

Figure 7: NANT-40

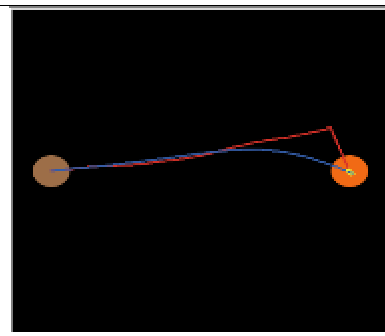

Figure 8: NANT-50

When the leader ant gets close enough to the food to "smell" it, it stops wiggling and heads directly for the food. The leader ant leaves a red trace as it moves. Each subsequent ant follows the ant ahead of it by heading directly towards it before it takes each step. The follower ants do not leave a trace. The yellow line of ants, however, traces out a curve in the drawing. The last ant to go leaves a blue trace. Hence from the above plots it is confirmed that as the number of ants increases for the foraging the chances for the shortest path is greater.

7. CONCLUSION:

Swarm Intelligence (SI) based ACO algorithms provide interesting solutions to network routing problems. ACO based routing in MANETs will enhance the reliability and efficient packet delivery. They help in reducing control overhead due to their inherent scalable feature. This proves the potentiality of our approach which is problem-type-independent. Finally, it is concluded that the swarm intelligence approach is an effective algorithm to solve different kinds of problems. In this dissertation, the research in Swarm Intelligence focused on two general approaches. One approach was to solve the optimization-like problems using the swarm-based algorithms as tools, and the other approach was to model the multi-agent systems such that they resemble swarms of animals in nature providing them with the ability to autonomously perform a task at hand.

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