SWARM INTELLIGENCE

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Introduction

- Nature has guided us to watch and learn the intelligent mechanism evolved by it
- The biologist over years have been puzzled by the various activities of organisms like marching of ant in an army, the waggle dance of honey bee, the nest building of social wasp, birds flocking in high skies, fish schools in deep waters, foraging activities of microorganisms, the construction of termite mound
- Many instances of creativity in animals arises from *collective behavior*, not from single individual's actions
- Swarm Intelligence is used for the collective behavior of a group of animals as a single living creature, where collective intelligence emerges via grouping and communication, resulting in more successful foraging for each individual in a group

Introduction

- Swarm Intelligence is a specialization in the field of self-organizing systems (*Adaptation*),
  - *Robustness*: When a route of ant is blocked, this can be observed that they find other new shortest new route to their destination
  - *Reliable*: Agents can be added or removed without compromising the total system
  - *Simplicity*: Single part may break down without impairing the overall system such that complex system are convenient to work
- The desired characteristics emerge from the interaction of the various parts without explicit supervision or central control system which is intelligent behavior
- Knowledge is distributed and becomes apparent in the interaction between the agents and the environment
- *Optimal foraging policy :* Animal search for and obtain nutrients in a way that maximizes their energy intake per unit time spent foraging

Background of Ant Intelligent System

- In 1991 Marco Dorigo and his colleague proposed ant algorithm as multi agent approach to solve difficult combinatorial optimization problem
- Ant algorithms were first tested and validated on the Travelling Salesman Problem
  - Reasons behind choosing TSP are:
    - It is a shortest path problem for which the ant colony metaphor can easily be adopted
    - The main idea is that of having a set of agents, called ants, search in parallel for good solutions and cooperate through the pheromone-mediated indirect method of communication
- Other history will be provided in Note

Importance of Ant Colony Paradigm

- Ant Colony Intelligent System is being used as an intelligent tools to help researchers to solve many problems in different areas of science and technology
- Scientists, now a days, are using real ant colonies to solve many combinatorial optimization problems in different engineering applications
- Traditional, sequential, logic-based digital computing excels in many years
- Features like positive feedback, distributed computation, and constructive greedy heuristics approaches made ACIS successful with tremendous potential

Ant Colony System

- An artificial ant colony system is a random stochastic population-based heuristic algorithm of agent that simulate the natural behavior of ants, developing mechanisms of cooperation and learning, which enables the exploration of the positive feedback between agents as a search mechanism.
- **Biological Ant colony System**
  - Ants perform their task autonomously without central coordination
  - When they act as a community they can solve complex problems emerging in their daily lives through mutual cooperation known as swarm intelligence
  - Swarm intelligence encompasses **a**) positive feedback **b**) negative feedback (saturation, exhaustion, competition) **c**)amplification of fluctuation (random walk) **d**) mutual interaction

Ant Colony System

- **Artificial Ant colony System**
  - A colony of cooperating individuals, an artificial pheromone trail, a sequence of local moves for finding the shortest path, a stochastic decision policy using local information
  - Artificial ant lives in a discrete world and their moves consists of transitions from discrete state to discrete state
  - Artificial ants have an internal states
  - Artificial ants deposits a particular amount of pheromone, which is the function of the quality of the solution found

Development of Ant Colony System

- Ant System was the first example of an Ant Colony Optimization which consists of three algorithms which was proposed by Dorigo in 1992
  - Ant Cycle
  - Ant Density
  - Ant quality
- In ant density and ant quality, ants can update pheromone trail directly after a move from one node to an adjacent node.
- In ant cycle update was carried out only after all the ants had constructed their tours and amount of pheromone deposited by each ant was set of function denoting the tour quality

Application of Ant Colony Intelligence

- The application of Ant Colony Intelligence is distinguished in two areas:
- ***Static Combinatorial Optimization Problem and Dynamic Combinatorial Optimization Problem***
- *Static Combinatorial Optimization Problem:*
  - characteristics of problem are defined and do not chance till the problem is solved
  - Ex: TSP, Graph coloring, vehicle routing etc
- *Dynamic Combinatorial Optimization Problem*
  - Some values are set by the dynamics of an underlying system
  - Problem changes on the fly so runtime and optimization algorithm must be capable of adapting on the fly to changing environment
  - Ex: Communication Networks

Working of Ant Colony System

- Focuses on following two rules
  - Specifying how ants construct or modify a solution for the problem in hand
  - Updating pheromone trail
- Incorporates two basic activities:
  - ***Probabilistic transition rule:***
  - Pheromone Updating