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Amorphous Computing and Swarm Intelligence

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Abstract:
This paper studies about amorphous computing and swarm intelligence. Here it describes how amorphous computing can be related to self-organizing systems, emergent behaviors, etc., but there is an important difference: Amorphous computing is an engineering discipline. Also describes two algorithms: DM and RD. In swarm intelligence, it describes how a group of ants get together to perform a particular task with unity. Here it describes two algorithms: PSO and ACO. Swarm intelligence (SI) is an artificial intelligence type based on the collective behavior of decentralized, self-organized systems. The expression was developed by Gerardo Beni and Jing Wang in 1989.Swarm intelligence depends on the stigmergic principles. In order to solve complex problems using simple agents. Agents may be ants, bees, bacteria, etc. Stigmergy- indirect interactions individual modifies the environment which in turn modifies the behavior of other individuals.

Keywords: DM, RD, PSO, ACO, Stigmergy, Artifical Intelligence, Decentralized.

1. INTRODUCTION

1.1. SWARM INTELLIGENCE

Swarm intelligence is an Artificial intelligence method based on the collective behavior of agents in decentralized, self-organized systems. It is generally made up of agents and the environment who interact with each other.

Real life examples of swarm intelligence are a flock of birds sweeps across the sky, a group of ants forages for food, a school of fish swims, turns, flees together etc. we call this kind of aggregate motion as Swarm behavior. Recently, scientists have studied how to achieve certain goals, and evolve. It does not have any centralized control structure. It is based on group behavior in nature.

To achieve their objectives, The agents use simple local protocols to control their actions. Swarm intelligence is the emergentcollective technologies of groups of simple autonomous agents.

The individual agents do not follow any leaders words. For example, when a bird gets involved in a flock, it only adjusts its some movements to control with the movements of its flock mates.

A bird in a flock simply tries to stay close to its neighbors, but avoid collisions with them. There is no Lead bird thus no one is controlled. Thus none of them take commands from leader bird. Any bird can fly in the front, center or back of the swarm.

Swarm behavior helps birds to take advantage of different things including protection from predators and searching for food. Some of the characteristics of swarm intelligence are: it is composed of many individuals, individuals are homogenous, local interactions based on simple rules, self-organization.

Figure.1. Swarm of Ants

1.2. AMORPHOUS COMPUTING

Amorphous computing is a sort of computing without a Predefined form or structure, as its name indicates. An amorphous computing system is a large collection of irregularly placed, locally interacting, identically-programmed, asynchrony ous computing elements. We assume that these agents communicate within a fixed radius, which is large relative to the size of an element, but small relative to the diameter of the system. The aim of amorphous computing is to create algorithms and techniques for the understanding of programming materials. Essentially, amorphous computing looks to incorporate the biological mechanisms of individual cells into systems that exhibit the expressive power of digital logic circuits. Amorphous computing gives an analog approach to swarm system design. A colony of cells swarms to form a multi-cellular organism under the control of an organism that is already a member of the colony.

2. SWARM INTELLIGENCE ALGORITHMS

2.1. ANT COLONY OPTIMIZATION

This optimization technique is proposed by Marco Dorigo in the early 90s.The Heuristic optimization technique is inspired by

biological systems. It has become new and fruitful research area. This algorithm search for an optimal path between their colony and source of food. It is a Meta-heuristic optimization method. Generalization of this algorithm is that ants navigate from nest to food source. Ants are blind! Shortest path is discovered via pheromone trails. Each ant moves to that place where random Pheromone is deposited. Virtual trail accumulated on path segments. Path selected from different paths, present on possible paths from starting node. When Ant reaches the next node, It selects the next path and continue. Until it reaches the starting node Finished tour is a solution. Tour is analyzed for optimality. The Heuristic method is used for solving computational problems by obtaining a more efficient procedure. Soft computing technique is used for solving hard discrete optimization problems. In many special cases of the Ant Colony Optimization meta-heuristic has been proposed. The most successful ones are Ant System, Ant Colony System (ACS), and MAX-MIN Ant System (MMAS).

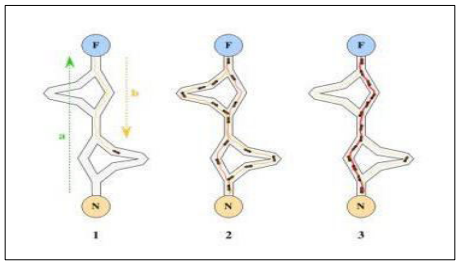

Figure.2. Ant find shortest path

2.2. PARTICLE SWARM OPTIMIZATION

This algorithm is proposed by James Kennedy & Russell Eberhart in 1995. Combines self-experiences with social experiences. Each particle controls its travelling speed by their own. Each particle modifies its position by:

- Its current position
- Its current velocity
- The distance between its current position and *p-best*
- The distance between its current position and *g-best*

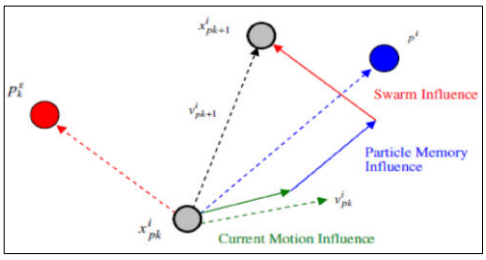

Figure.3. Concept of PSO

2.2.1. Algorithm parameters

- ***A*** : Population of agents
- p_i : Position of agent a_i is the solution space
- ***f*** : Objective function
- v_i : Velocity of agent's a_i
- $V(a_i)$: Neighborhood of agent a_i (fixed)

Intensification: It finds the best solution for a given region.
Diversification: It searches new solutions and finds the regions with potentially the best solutions.

The Formula used for the calculations are :

$$\mathbf{v}_i^{t+1} = \underbrace{\mathbf{v}_i^t}_{\text{Diversification}} + \underbrace{c_1\mathbf{U}_1^t(\mathbf{pb}_i^t - \mathbf{p}_i^t) + c_2\mathbf{U}_2^t(\mathbf{gb}^t - \mathbf{p}_i^t)}_{\text{Intensification}}$$

3. AMORPHOUS COMPUTING ALGORITHMS

3.1. DISTANCE MEASUREMENT

Initiating Message
1. Initiates the message.
2. The message contains a hop count where the anchor particle has initialized to 0.
3. Diffusion wave propagation.

Diffusion wave propagation
1. While particle exist
2. If count is higher than ignore it
3. Else
4. Increase the hop count
5. Propagate the message.

3.2. REGION DEFINITION

1. While particle exist
2. Create an ID using random number generator.
3. Identify the set of particles to communicate.
4. Initialize a state variable LOWNUM must equal to its particle ID.
5. If a neighbor's LOWNUM< than its own LOWNUM
6. LOWNUM= neighbor's LOWNUM
7. Computes a frequency table of the LOWNUM values and its neighbors.
8. Reset LOWNUM to the most frequency occurring LOWNUM value in its table.
9. Continue until stabilization occurs.
10. Propagate edge information (particle that sees more than one LOWNUM values near an edge).
11. Propagate vertex information (A particle that sees two or more LOWNUM values is near a vertex).
12. Combine all of the information through broadcast accumulation.

4. FUTURE SCOPE

- *Self assembling robots*: Each robot behaves autonomously and they can self-organize themselves to achieve certain goals. Each robot is given some amount of information allowing them to interact with each other and by limiting this amount of information we are able to make a swarm or cluster to solve a large problem.
- *Medicines*: Nanoparticles are used in medicines. Nanoparticles are too small to program, if nanoparticles can from a swarm, they can go to targeted cancer cells and gets can go to targeted cancer cells and gets activate there by some external energy and destroy targeted tissues.
- *Traveling salesman person*: This problem is to find the shortest distance that a salesman has to travel to every city but only once and to arrive back at his starting position.
- Evolving neural networks to solve problems.

- U.S. Military is applying Swarm Intelligence techniques to control of unmanned vehicles.
- For planetary mapping, NASA applying SI Techniques.
- Medical Researchers are trying SI based controls for Nano-robots to fight cancer in humans.

5. CONCLUSION

SI provides heuristics to solve difficult optimization problems. Has wide variety of applications. Basic philosophy of swarm intelligence is to see the behavior of animals and try to act like those animals on computer systems. The Basic theme of Natural computing are observe nature, mimic nature. First, sensor network simulation tools need to be constructed; theoretical analysis should occur in parallel possibly providing bounds on performance when analytical Closed-form solutions cannot be easily obtained. The existing bodies of sensor network routing algorithms are either incompletely specified or analyzed; considerable work remains to be done. Scenario generators should be built in order to evaluate the effectiveness of the sensor network – the environment – in conjunction with agents whose behavior is stigmergically-driven. In order to achieve this, an extensible, reusable agent framework should be developed that captures the patterns documented in this report, suitably augmented with existing intelligent agent algorithms for military applications. Research into the problem of combining stigmergic signals called as sensor fusion also needs to be conducted. Third, Research on intelligent materials needs to be undertaken. Also, The work on Amorphous Computing provides the potential for materials capable of self-repair. Self-Repairing materials have applications in the autonomous repair of unmanned autonomous vehicles. Finally, reconfigurable and self-reproducing robots research should be supported.. The goal should be to understand, fabricate and deploy modules in the battlefield setting that can be used as building blocks for the repair and reproduction of unmanned autonomous vehicles in situation.

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