A

Seminar report

On

Swarm Intelligence (SI)

Submitted in partial fulfillment of the requirement for the award of degree
Of ECE

SUBMITTED TO:

SUBMITTED BY:

Acknowledgement

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Preface

I have made this report file on the topic **Swarm Intelligence (SI)**; I have tried my best to elucidate all the relevant detail to the topic to be included in the report. While in the beginning I have tried to give a general view about this topic.

My efforts and wholehearted co-corporation of each and everyone has ended on a successful note. I express my sincere gratitude to …………..who assisting me throughout the preparation of this topic. I thank him for providing me the reinforcement, confidence and most importantly the track for the topic whenever I needed it.

ABSTRACT

Swarm intelligence (SI) is the collective behaviour of decentralized, self-organized systems, natural or artificial. The concept is employed in work on artificial intelligence. The expression was introduced by Gerardo Beni and Jing Wang in 1989, in the context of cellular robotic systems.

SI systems are typically made up of a population of simple agents or boids interacting locally with one another and with their environment. The agents follow very simple rules, and although there is no centralized control structure dictating how individual agents should behave, local, and to a certain degree random, interactions between such agents lead to the emergence of "intelligent" global behavior, unknown to the individual agents. Natural examples of SI include ant colonies, bird flocking, animal herding, bacterial growth, and fish schooling.

The application of swarm principles to robots is called swarm robotics, while 'swarm intelligence' refers to the more general set of algorithms. 'Swarm prediction' has been used in the context of forecasting problems.

Contents

Ant colony optimization

Ant colony optimization (ACO) is a class of optimization algorithms modeled on the actions of an ant colony. ACO methods are useful in problems that need to find paths to goals. Artificial 'ants'—simulation agents—locate optimal solutions by moving through a parameter space representing all possible solutions. Real ants lay down pheromones directing each other to resources while exploring their environment. The simulated 'ants' similarly record their positions and the quality of their solutions, so that in later simulation iterations more ants locate better solutions.[2] One variation on this approach is the bees algorithm, which is more analogous to the foraging patterns of the honey bee.

River formation dynamics

River formation dynamics (RFD)[3] is an heuristic method similar to ant colony optimization (ACO). In fact, RFD can be seen as a gradient version of ACO, based on copying how water forms rivers by eroding the ground and depositing sediments. As water transforms the environment, altitudes of places are dynamically modified, and decreasing gradients are constructed. The gradients are followed by subsequent drops to create new gradients, reinforcing the best ones. By doing so, good solutions are given in the form of decreasing altitudes. This method has been applied to solve different NP-complete problems (for example, the problems of finding a minimum distances tree and finding a minimum spanning tree in a variable-cost graph[4]). The gradient orientation of RFD makes it specially suitable for solving these problems and provides a good tradeoff between finding good results and not spending much computational time. In fact, RFD fits particularly well for problems consisting in forming a kind of covering tree.[5]

Particle swarm optimization

Particle swarm optimization (PSO) is a global optimization algorithm for dealing with problems in which a best solution can be represented as a point or surface in an n-dimensional space. Hypotheses are plotted in this space and seeded with an initial velocity, as well as a communication channel between the particles[6][7]. Particles then move through the solution space, and are evaluated according to some fitness criterion after each timestep. Over time, particles are accelerated towards those particles within their communication grouping which have better fitness values. The main advantage of such an approach over other global minimization strategies such as simulated annealing is that the large number of members that make up the particle swarm make the technique impressively resilient to the problem of local minima.

Stochastic diffusion search

Stochastic diffusion search (SDS) is an agent-based probabilistic global search and optimization technique best suited to problems where the objective function can be decomposed into multiple independent partial-functions. Each agent maintains a hypothesis which is iteratively tested by evaluating a randomly selected partial objective function parameterised by the agent's current hypothesis. In the standard version of SDS such partial function evaluations are binary, resulting in each agent becoming active or inactive. Information on hypotheses is diffused across the population via inter-agent communication. Unlike the stigmergic communication used in ACO, in SDS agents communicate hypotheses via a one-to-one communication strategy analogous to the tandem running procedure observed in some species of ant. A positive feedback mechanism ensures that, over time, a population of agents stabilise around the global-best solution. SDS is both an efficient and robust search and optimisation algorithm, which has been extensively mathematically described.

Gravitational search algorithm

Gravitational search algorithm (GSA) is constructed based on the law of Gravity and the notion of mass interactions. The GSA algorithm uses the theory of Newtonian physics and its searcher agents are the collection of masses. In GSA, we have an isolated system of masses. Using the gravitational force, every mass in the system can see the situation of other masses. The gravitational force is therefore a way of transferring information between different masses.(Barry Webster and Philip Bernhard, 2003)

Intelligent Water Drops

Intelligent Water Drops algorithm (IWD) is a swarm-based nature-inspired optimization algorithm, which has been inspired from natural rivers and how they find almost optimal paths to their destination.These near optimal or optimal paths follow from actions and reactions occurring among the water drops and the water drops with their riverbeds. In the IWD algorithm, several artificial water drops cooperate to change their environment in such a way that the optimal path is revealed as the one with the lowest soil on its links. The solutions are incrementally constructed by the IWD algorithm. Consequently, the IWD algorithm [8] is generally a constructive population-based optimization algorithm.

Charged System Search

Charged System Search (CSS) [9] is a new optimization algorithm based on some principles from physics and mechanics. CSS utilizes the governing laws of Coulomb and Gauss from electrostatics and the Newtonian laws of mechanics. CSS is a multi-agent approach in which each agent is a Charged Particle (CP). CPs can affect each other based on their fitness values and their separation distances. The quantity of the resultant force is determined by using the electrostatics laws and the quality of the movement is determined using Newtonian mechanics laws. CSS is applicable to all optimization fields; especially it is suitable for non-smooth or non-convex domains. This algorithm provides a good balance between the exploration and the exploitation paradigms of the algorithm which can considerably improve the efficiency of the algorithm and therefore the CSS also can be considered as a good global and local optimizer simultaneously.

Applications

Swarm Intelligence-based techniques can be used in a number of applications. The U.S. military is investigating swarm techniques for controlling unmanned vehicles. The European Space Agency is thinking about an orbital swarm for self assembly and interferometry. NASA is investigating the use of swarm technology for planetary mapping. A 1992 paper by M. Anthony Lewis and George A. Bekey[10] discusses the possibility of using swarm intelligence to control nanobots within the body for the purpose of killing cancer tumors.

Crowd simulation

Artists are using swarm technology as a means of creating complex interactive systems or simulating crowds.

Stanley and Stella in: Breaking the Ice was the first movie to make use of swarm technology for rendering, realistically depicting the movements of groups of fish and birds using the Boids system. Tim Burton's *Batman Returns* also made use of swarm technology for showing the movements of a group of bats. The *Lord of the Rings* film trilogy made use of similar technology, known as Massive, during battle scenes. Swarm technology is particularly attractive because it is cheap, robust, and simple.

Airlines have used swarm theory to simulate passengers boarding a plane. Southwest Airlines researcher Douglas A. Lawson used an ant-based computer simulation employing only six interaction rules to evaluate boarding times using various boarding methods.(Miller, 2010, xii-xviii)[11].

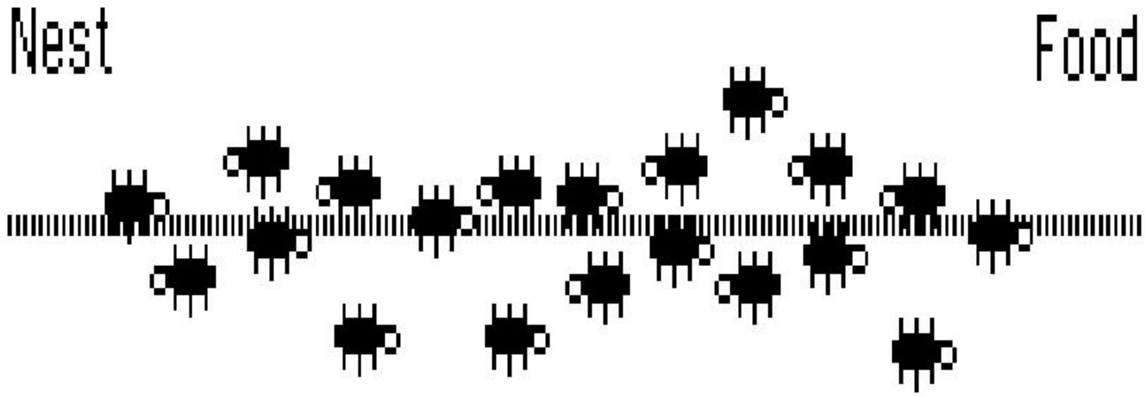
Ant-based routing

The use of Swarm Intelligence in Telecommunication Networks has also been researched, in the form of Ant Based Routing. This was pioneered separately by Dorigo et al. and Hewlett Packard in the mid-1990s, with a number of variations since. Basically this uses a probabilistic routing table rewarding/reinforcing the route successfully traversed by each "ant" (a small control packet) which flood the network. Reinforcement of the route in the forwards, reverse direction and both simultaneously have been researched: backwards reinforcement requires a symmetric network and couples the two directions together; forwards reinforcement rewards a route before the outcome is known (but then you pay for the cinema before you know how good the film is). As the system behaves stochastically and is therefore lacking repeatability, there are large hurdles to commercial deployment. Mobile media and new technologies have the potential to change the threshold for collective action due to swarm intelligence (Rheingold: 2002, P175).

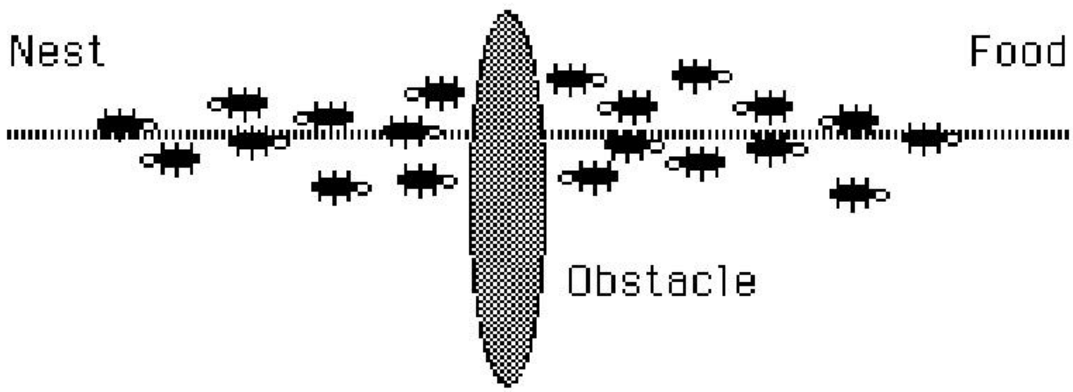
Airlines have also used ant-based routing in assigning aircraft arrivals to airport gates. At Southwest Airlines a software program uses swarm theory, or swarm intelligence -- the idea that a colony of ants works better than one alone. Each pilot acts like an ant searching for the best airport gate. "The pilot learns from his experience what's the best for him, and it turns out that that's the best solution for the airline," Dr. Douglas

A. Lawson explains. As a result, the "colony" of pilots always go to gates they can arrive and depart quickly. The program can even alert a pilot of plane back-ups before they happen. "We can anticipate that it's going to happen, so we'll have a gate available," Dr. Lawson says.

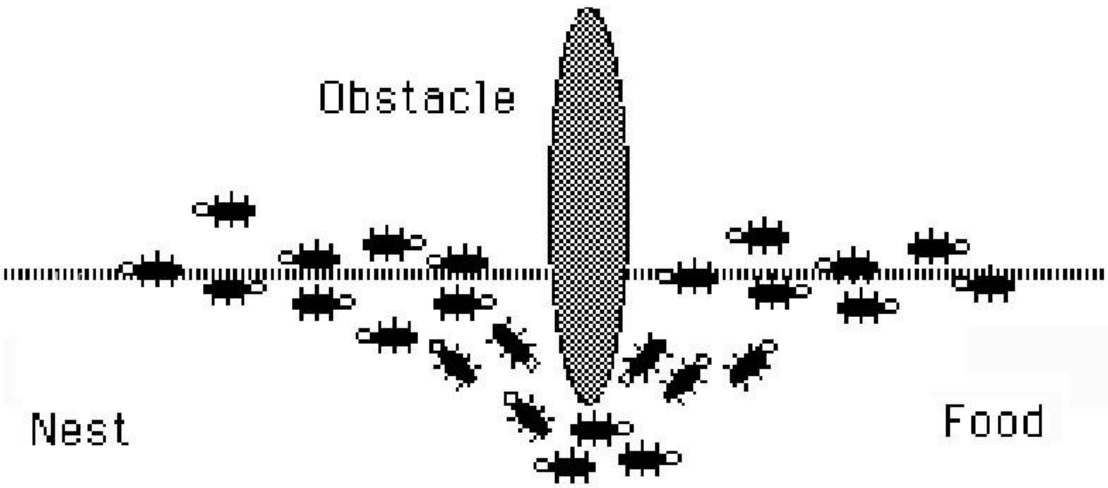
An In-depth Look at Real Ant Behavior



Interrupt The Flow



Adapting to Environment Changes



Advantages of SI

- The systems are scalable because the same control architecture can be applied to a couple of agents or thousands of agents
- The systems are flexible because agents can be easily added or removed without influencing the structure
- The systems are robust because agents are simple in design, the reliance on individual agents is small, and failure of a single agents has little impact on the system's performance
- The systems are able to adapt to new situations easily

Problems Regarding Swarm Intelligent Systems

- **Swarm Intelligent Systems are hard to ‘program’ since the problems are usually difficult to define**
  - **Solutions are emergent in the systems**
  - **Solutions result from behaviors and interactions among and between individual agents**

Possible Solutions to Create Swarm Intelligence Systems

- **Create a catalog of the collective behaviours (Yawn!)**
- **Model how social insects collectively perform tasks**
  - **Use this model as a basis upon which artificial variations can be developed**
  - **Model parameters can be tuned within a biologically relevant range or by adding non-biological factors to the model**

Travelling Salesperson Problem:

Initialize
    Loop /* at this level each loop is called an iteration */
    Each ant is positioned on a starting node
        Loop /* at this level each loop is called a step */
        Each ant applies a state transition rule to incrementally build a solution and a local pheromone updating rule
    Until all ants have built a complete solution
A global pheromone updating rule is applied
Until End_condition

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