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A STUDY ON EFFICIENT LOCALIZATION METHODS USING SWARM INTELLIGENCE

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Abstract: Wireless sensor network (WSN) refers to a group of spatially dispersed and dedicated sensors for monitoring and recording the physical conditions of the environment and organizing the collected data at a central location. Localization is a fundamental challenge in WSN. Optimization technique is used to obtain the best solution for localization. The two optimization are used best solution for improving of localization problems in wireless sensor networks namely, Ant Colony Optimization (ACO) and particle swarm Optimization (PSO). Both are natural inspired phenomena which are based on swarm intelligence. In this paper, we describe the main concepts of swarm intelligence and comparison between two optimization techniques, their basic ideas, advantages, disadvantages, applications and energy efficient distributed localization technique is proposed. Distributive localization is addressed using Particle Swarm Optimization.

Keywords: Localization, Particle swarm optimization,, Ant Colony Optimization, Swarm intelligence.

I. INTRODUCTION

Wireless sensor networks (WSNs) are essentially intended to observe spatiotemporal characteristics of the physical world. A promising WSN application is long-term surveillance in hostile or distant environments. Using WSNs for military surveillance, for example, involves deploying numerous sensors throughout the region of interest by aircraft to detect enemy activity or equipment [1. These sensors sense physical characteristics of the world. The sensors could be measuring a variety of properties, including distance, temperature, acoustics, light, and pollution etc. Base stations are responsible for sending queries to and collecting data from the sensor nodes. Swarm Intelligence [B. K. Panigrahi, Y. Shi, and M.-H. Lim] is an innovative, distributed intelligent paradigm for solving optimization problems that organized from the study of colonies, or swarm of social organisms. Studies of the social behavior of organisms (individuals) in swarm prompted the design of very efficient optimization and clustering algorithms. The state of the art clustering algorithms based on swarm intelligence tool are Particle Swarm Optimization (PSO) and Ant Colony Optimization (ACO). ACO is a Meta heuristic for solving combinatorial optimization problems. It is

inspired by the way real ants find shortest paths from their nest to food sources. An essential aspect thereby is the indirect communication of the ants via pheromone, i.e., a chemical substance which is released into the environment and that influences the behavior or development of other individuals of the same species. Ants mark their paths to the food sources by laying a pheromone trail along their way. The pheromone traces can be smelled by other ants and lead them to the food source. PSO is a Meta heuristic that is mainly used for finding maximum or minimum values of a function [Kennedy et al., 2001]. PSO is inspired by the behavior of swarms of fishes or flocks of birds to find a good food place. PSO is a population-based search procedure where the individuals, referred to as particles, are grouped into a swarm. Each particle in the swarm represents a candidate solution to the optimization problem
The objective of this paper is to:

- Concepts of swarm intelligence. - Review.
- Design of position estimation using PSO

2. Swarm Intelligence

Swarm intelligence (SI) [HS Sridhar, Dr.M Siddappa] is a relatively novel field that was originally defined as "Any attempt to design algorithms or distributed problem-solving devices inspired by the collective behavior of social insects and other animal societies". However, nowadays it refers more generally to the study of the collective behavior of systems composed of many components that coordinate using decentralized controls and self-organization provides a basis with which it is possible to explore collective (or distributed) problem solving without centralized control or the provision of a global model. Leverage the power of complex adaptive systems to solve difficult non-linear stochastic problems.

2.1 Characteristics of a swarm:

- Distributed, no central control or data source;
- Limited communication
- No (explicit) model of the environment;
- Perception of environment (sensing)
- Ability to react to environment changes.
- Social interactions (locally shared knowledge) provides the basis for unguided problem solving
- The efficiency of the effort is related to but not dependent upon the degree or connected ness of the network and the number of interacting agents
- Robust exemplars of problem-solving in Nature
- Survival in stochastic hostile environment
- Social interaction creates complex behaviors
- Behaviors modified by dynamic environment.

3. Ant Colony Optimization

ACO technique comes under the swarm intelligence [Daniel Merkle and Martin Middendorf]. It is used in various dynamic applications. Ants started from nest in the search of food which is away from nest. Each ant follow different path to reach to the food source and secrete pheromone liquid at the path as a mark to attract other ants. Ants choose the path depending upon the pheromone and path is marked after collecting food. So at the end shortest path has the highest probability. The act of making trail of pheromone liquid is very useful to find out good food source direction. Moreover, ACO [Daniel Merkle and Martin Middendorf] deals with a process in which decreasing in amount of pheromone deposited on every path by the time is known as trail pheromone evaporation. When they complete their search to find out best result or to reach final destination, they update their trail to attract other ants. Each conspiratorial problem defines its own updating criteria depending on its own local search and global search respectively. Ants are able to find shortest path on the basis of pheromone information laid on ground by other ants of same colony. Ant searching for food goes for all possible trails, but in last chooses the trail with largest deposit pheromone and update according to the latest pheromones. There is population of ants in ants system, which is working as agent to find out shortest path and communicate with other ants. When reached its destination, the

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direction of path it follow is based upon the amount of pheromone it detects and is made by decision probabilistic. The whole process shows team coordination, synchronization, team management, how to communicate with others ants.

3.1 Ant Colony Optimization Algorithm (AC0)

A scheme of an ACO algorithm and flowchart in figure 1 is given in the following.

ACO scheme:

1. Represent the solution space by a construction graph.
2. Set ACO parameters and initialize pheromone trails
3. Generate ant solutions from each ant‘s walk on the construction graph mediated by pheromone trails.
4. Update pheromone intensities.
5. Go to step 3, and repeat until convergence or termination conditions are met.

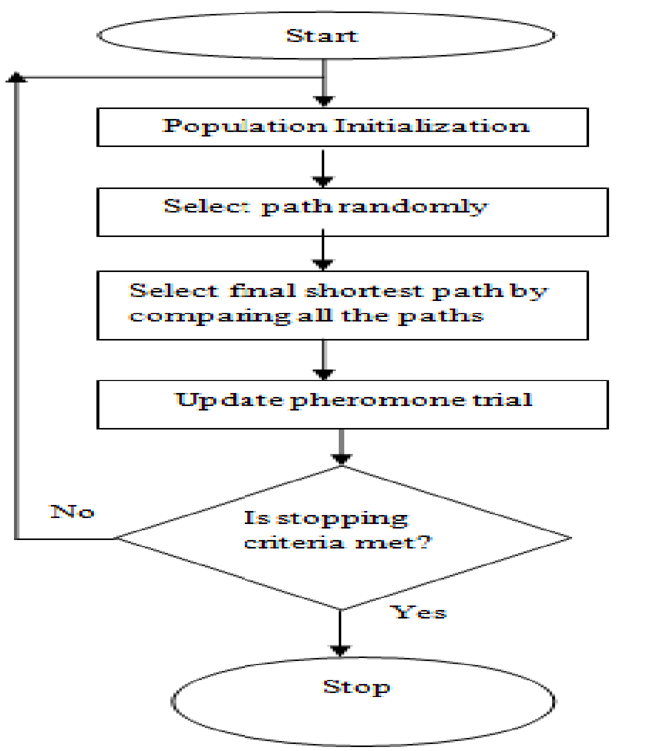

Figure 1: Basic ACO

3.2 Advantages of ACO

1. ACO displays powerful robustness.
2. It has an advantage of distributed computation which avoids premature convergence.
3. It is adaptive in nature and can adapt changes easily.
4. It gives positive feedback which leads to discovery of good solutions.
5. It can be used in dynamic applications.
6. To communicate with each other’s ant use antennas and pheromone liquid.
7. The whole process is done in an organized manner.

3.3 Disadvantages of ACO

1. Its convergence is guaranteed but time to convergence is uncertain.
2. Coding is not straightforward.
3. It is prone to falling in the local optimal solution.

3.4 Applications of ACO

ACO is used in routing problem i.e. traveling salesman problem, vehicle routing and sequential ordering.

1. It is applied to solve job scheduling problem, project scheduling and applied in multilevel framework also.
2. It is also used to solve many assignment problems like frequency assignment, graph coloring and quadratic assignment problem.
3. ACO is also applied in the field of networking like optical network routing, connection oriented routing etc.
4. It can be used to solve knapsack problem and set covering problems and applied in fuzzy systems.
5. Nearest neighbor node choosing rule can be solved by using ant colony optimization.

4. Particle Swarm Optimization (PSO).

Particle swarm optimization algorithms are also a subset of SI. The basic concept of PSO is inspired by the social behavior of bird flocking and fish schooling. More precisely, PSO is a parallel evolutionary computation technique that provides a collaborative population-based search model. Individuals of the population called particles fly around in a multidimensional search space. During flight, each particle adjusts its position according to its own experience and according to the experience of a neighboring particle, moving toward the best position encountered by itself or its neighbors. Thus, the PSO system combines local search methods (through self-experience) with global search methods (through neighboring experience), attempting to balance exploration and exploitation .In practice, a PSO algorithm is initialized with a population of random candidate solutions or particles. Two factors characterize a particle status on the search space: its position and its velocity. Additionally, the performance of each particle is measured according to a problem-dependent fitness function (i.e., cost function). Each particle is assigned a randomized velocity and is iteratively moved through the problem space. It is attracted towards the location of the best fitness achieved so far by the particle itself and by the location of the best fitness achieved so far across its neighborhood. Two versions of PSO exist depending on the neighborhood topology used to exchange experience among particles. In the global version of the algorithm, the neighborhood of the particle is the entire population (i.e., the entire swarm). In the local version, the swarm is divided into overlapping neighborhoods of particles.

4.1 Basic flow of PSO

PSO Algorithm:

A scheme of PSO algorithm and flowchart in figure 2 is given in the following.

Step-1: Initialize the population - position and velocities
Step-2: Evaluate the fitness of the individual particle (pBest)
Step-3: Keep track of the individual's highest fitness (gBest)
Step-4: Modify velocities based on pBest and gBest position.
Step-5: Update the particles position
Step-6: Terminate if the condition is met
Step-7: Go to Step 2.
Update the velocities of all the particles
Using equation 1&2

$$V_{id}(K) = wV_{id}(k-1) + C_1R_1\big(P_{id}(t) - X_{id}(t)\big) + C_2R_2\left(P_{gd}(t) - X_{id}(t)\right) \quad (1)$$

Move each particle to its new position

$$xid(t+1) = xid(t) + vid(t+1) \quad ----- \quad (2)$$

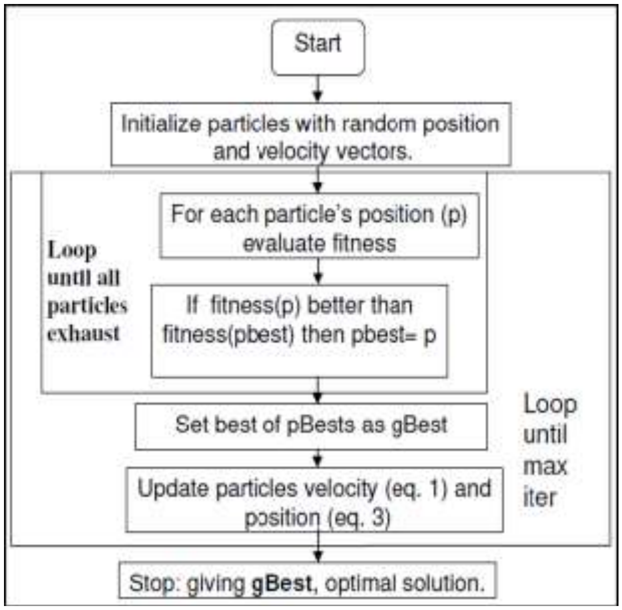

Figure 2: A general flow chart of PSO

Here, r1 and r2 are the random numbers with a uniform distribution in the range [0, 1]. Velocity update is dependent on three components of acceleration. W is the inertia of the particle which changes linearly in each iteration $0.2 \leq w \leq 0.9$.

4.2 Advantages of PSO:

1. PSO is based on the intelligence. It can be applied into both scientific research and engineering use.
2. PSO has no overlapping and mutation calculation. The search can be carried out by the speed of the particle. During the development of several generations, only the most optimist particle can transmit information onto the other particles, and the speed of the researching is very fast.
3. The calculation in PSO is very simple. Compared with the other developing calculations, it occupies the bigger optimization ability and it can be completed easily.
4. PSO adopts the real number code, and it is decided directly by the solution. The number of the dimension is equal to the constant of the solution.

4.3 limitations of PSO:

1. The method easily suffers from the partial optimism, which causes the less exact at the regulation of its speed and the direction.
2. The method cannot work out the problems of scattering and optimization.
3. The method cannot work out the problems of non-coordinate system, such as the solution to the energy field and the moving rules of the particles in the energy field

4.4 Applications of PSO:

The first practical application of PSO was in the field of neural network training and was reported together with the algorithm itself. Many more areas of application have been explored ever since, including telecommunications, control, data mining, design, combinatorial optimization, power systems, signal processing, and many others. Although PSO has been used mainly to solve unconstrained, single-objective optimization problems, PSO algorithms have been developed to solve constrained problems, multi-objective optimization problems, problems with dynamically changing landscapes, and to find multiple solutions.

5. Comparison between the two discussed SI Models: ACO vs. PSO

Criteria	ACO	PSO
Communication Mechanism	ACO uses an indirect communication mechanism among ants, called stigmergy, which means interaction through the environment.	The communication among particles in PSO is rather direct without altering the environment.
Problem Types	ACO was originally used to solve combinatorial (discrete) optimization problems, but it was later modified to adapt continuous problems.	PSO was originally used to solve continuous problems, but it was later modified to adapt binary/ discrete optimization problems.
Problem Representation	ACO's solution space is typically represented as a weighted graph, called construction graph.	PSO's solution space is typically represented as a set of n-dimensional points.
Algorithm Applicability	ACO is commonly more applicable to problems where source and destination are predefined and specific.	PSO is commonly more applicable to problems where previous and next particle positions at each point are clear and uniquely defined.
Algorithm Objective	ACO's objective is generally searching for an optimal path in the construction graph.	PSO's objective is generally finding the location of an optimal point in a Cartesian coordinate system.

Table 1: Comparison between ACO and PSO

6. PSO Based WSN Localization

WSN localization in a network of total in sensor nodes is to estimate the coordinates of n target nodes using the a priori information about the location of m- n anchor nodes. Thus for a 2D location problem a total of 2n unknown coordinates

θ =[θx, θy]; θx =[x1,x2,. x_n], θy=[Y1,Y2 ...Yn],are to be estimated using the anchor node coordinates[xn+1,….,xn+m,] and [Yn+1,….,Yn+m,] [Divya P. L, Raghavendra V,Kulkarni, Rekha Manoj]

The position estimation of the coordinates of the target nodes can be formulated as an optimization problem, involving the minimization of an objective function representing the error in locating the target nodes. The sum of squared range errors between the target nodes and neighboring anchor nodes can be considered The ranging errors originate from the inaccuracies in the underlying range measurement techniques.

Let (x,y) be the coordinates of the target node to be determined and d_i be the distance between the target node and the i^{th} anchor node.

$$d_i = \sqrt{(x - x_i)^2 + (y - y_i)^2} \quad \text{-----------} \quad 3$$

Let di be the value obtained from the noisy range measurements. The objective function for the localization problem can be gamed as

$$f(x,y) = \frac{1}{M}\sum_{i=1}^{M}\left(\sqrt{(x - x_i)^2 + (y - y_i)^2} - d_i\right)^2 \text{-------} \quad 4$$

where M >_ 3 is the number of anchor nodes with in the transmission range of the target node

(x_i, y_i) = coordinates of i^{th} anchor node

(x, y)= coordinates of node to be estimated

6.1 Position estimation using PSO

Implementation of the PSO method for WSN localization is as follows. For each target node the following steps are executed.

Step1: Selection of initial configuration the centroid of the anchor nodes within the transmission range of the target node is a good initial estimate of the solution. The value of gbest is initialized with the position of the centroid.

$$(x_c, y_c) = \left(\frac{1}{M}\sum_{i=1}^{M} x_i , \frac{1}{M}\sum_{i=1}^{M} y_i\right)$$

Step2: The group of' K particles is initialized with the random positions using polar coordinates, with the centroid as the origin. The pbest is initialized with this value of particle positions. Also the initial velocity of all particles is set to zero.

Step3: For each particle, evaluate the objective function. If I" particle's current objective function value is better than that of pbest,, update pbest with the current location of the particle.

Step4: Update gbest with the particle with best objective function value in the particle population.

Step5: For each particle, update the velocity and position according to the Equations (1) and (2) respectively.

Step6: Steps 3-5 are repeated till either the threshold values of objective function or the maximum number of iterations are achieved.

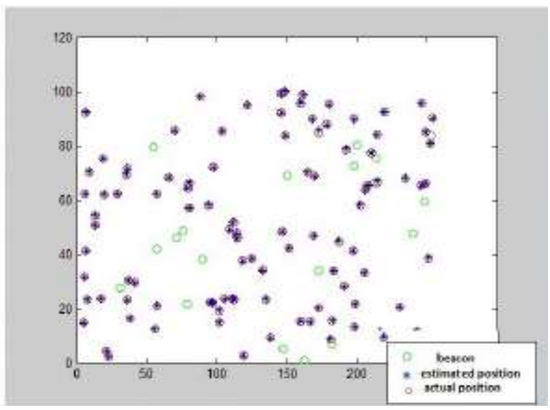

Figure 3. PSO based Localization

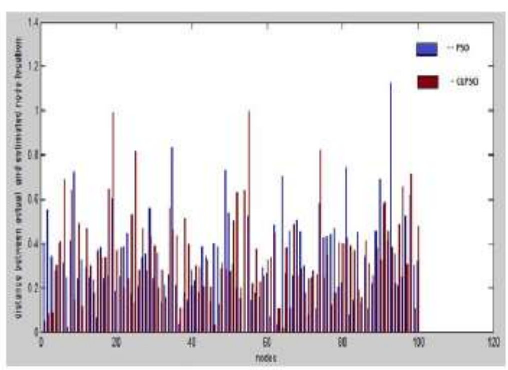

Figure 4: Distance between actual position and Estimated position for PSO

V. CONCLUSION

In this paper, the main concepts of Swarm Intelligence are presented, with a particular focus on two of the most successful inspired optimization techniques: Ant Colony Optimization and Particle Swarm Optimization, and their comparisons, their basic ideas, advantage, disadvantages and applications. We analyzed a algorithm for the localization in WSN using the PSO technique. The proposed survey can provide the possibility to design the better solution for localization.

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