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A Survey of Shortest-Path Algorithms

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Abstract

A shortest-path algorithm finds a path containing the minimal cost between two vertices in a graph. This paper presents a survey of different shortest-path algorithms used for different purposes. We also propose to design a shortest path routing Algorithm using Particle Swarm Optimization for Wireless Sensor Network on which if we send the data packets it will take less time, less energy so that the battery utilization will be minimized.

Keywords: Shortest-Path Algorithms, WSN, PSO.

INTRODUCTION

The shortest-path problem is one of the well-studied topics in computer science, specifically in graph theory. An optimal shortest-path is one with the minimum length criteria from a source to a destination. There has been a surge of research in shortest-path algorithms due to the problem's numerous and diverse applications. These applications include network routing protocols, route planning, traffic control, path finding in social networks, computer games, and transportation systems, to count a few. Generally, in order to represent the shortest path problem we use graphs. A graph is a set of vertices and edges and each edge connects to the vertices .Along the edges of a graph it is possible to walk by moving from one vertex to other vertices. Depending on whether or not one can walk along the edges by both sides or by only one side determines if the graph is a directed graph or an undirected graph. The lengths of edges are often called weights, and the weights are normally used for calculating the shortest path from one point to another point. There are many algorithms to calculate the shortest path problem. The different shortest path algorithms are Dijkstra algorithm, Bellman-Ford algorithm, Floyd-Warshall algorithm Genetic algorithm Particle Swarm optimization etc.

This paper presents a survey of various shortest paths calculated using different algorithms and how it has been used for different applications. The rest of the paper is organized as follows. Section II gives a study about different shortest paths algorithms done till date. Section III provides a brief description of our problem statement along with the methodology we would adopt to solve our stated problem. Finally Section IV presents the conclusion and future work to be done.

RELATED WORK

The main objective of this paper[1] was to study and experiment the different shortest path algorithms to be used in navigation system such as Dijkstra's algorithm, Symmetrical Dijkstra's algorithm, A* algorithm, Bellman-Ford algorithm, Floyd-Warshall algorithm and Genetic algorithm in solving the shortest path problem. The result showed that the performance of Bellman Ford algorithm was superior to other algorithm in most situations. So the authors have concluded that the Bellman-Ford algorithm is the most efficient shortest path algorithm as compared to others. On other hand, the genetic algorithm was shown to have highest running time but was able to produce the optimum solution in most situations. The experiment also shows that performance of genetic algorithm was affected by its number of generation where the larger the number of generation, the higher the running times as well as the better the solution. Thus, it is important to adjust the number of generation until the optimum running time to solution ratio was achieved so that the genetic algorithm can be used in the most efficient manner. In transport planning, one should allow passengers to travel through the complicated transportation scheme with efficient use of different modes of transport. In this paper [2]the authors have proposed the use of a cockroach swarm optimization algorithm for determining paths with the shortest travel time. In this approach, the algorithm has been modified to work with the time-expanded model. Therefore the authors have presented how the algorithm has to be adapted to this model, including correctly creating solutions and defining steps and movement in the search space. By introducing the proposed modifications, they are able to solve journey planning. The results have shown that the performance of their approach, in terms of converging to the best solutions, is satisfactory. Moreover, they have compared their results with Dijkstra's algorithm and a particle swarm optimization algorithm. In this paper[3], the authors have proposed a new approach for computing multi-modal shortest paths. They only considered railway, bus and pedestrian networks. The travel time is the only metric in their cost function. The proposed approach is a combination of two meta-heuristics: Genetic Algorithm (GA) and Variable Neighborhood Search (VNS). The authors have compared their approach with the exact shortest path algorithm Dijikstra that has been modified to work in a multimodal environment, as well as, with a pure GA. Results have shown that the success rate of new approach in terms of converging to optimum/near optimum solutions is highly better than a pure GA. Moreover, in contrast to traditional algorithms like Dijkstra, the new approach proposed is fast enough for practical routing applications. The Shortest Path (SP) problems are conventional combinatorial optimization problems. There are many deterministic algorithms for solving the shortest path problems in static topologies. However, in dynamic topologies, these deterministic algorithms are not efficient due to the necessity of restart. In [4], an improved Genetic Algorithm (GA) with four local search operators for Dynamic Shortest Path (DSP) problems has been proposed. The local search operators are inspired by Dijkstra's Algorithm and carried out when the topology changes to generate local shortest path trees, which are used to promote the performance of the individuals in the population. The experimental results showed that the proposed algorithm could obtain the solutions which adapt to new environments rapidly and produce high-quality solutions after environmental changes. This paper [5] presented the investigations on the application of particle swarm optimization (PSO) to solve shortest path (SP) routing problems. A modified priority-based encoding incorporating a heuristic operator for reducing the possibility of loop-formation in the path construction process has been proposed for particle representation in PSO. Simulation experiments have been carried out on different network topologies for networks consisting of 15–70 nodes. It was noted that the proposed PSO-based approach can find the optimal path with good success rates and also can find closer sub-optimal paths with high certainty for all the tested networks. It was also observed that the performance of the proposed algorithm surpasses those of recently reported genetic algorithm based approaches for this problem. End-to-end delay, power consumption, and communication cost are some of the most important metrics in a mobile ad hoc network (MANET) when routing from a source to a destination. In this work [6],a hybrid routing intelligent algorithm that has an ant colony optimization (ACO) algorithm and particle swarm optimization (PSO) has been used to improve the various metrics in MANET routing. The ACO algorithm uses mobile agents as ants to identify the most feasible and best path in a network. Additionally, the ACO algorithm helps to locate paths between two nodes in a network and provides input to the PSO technique, which is a meta-heuristic approach in SI. The PSO finds the best solution for a particle's position and velocity and minimizes cost, power, and end-to-end delay. This hybrid routing intelligent algorithm has an improved performance when compared with the simple ACO algorithm in terms of delay, power consumption, and communication cost. In the paper[7], the authors have investigated the shortest path problem based on the genetic algorithm principle, an improved self-adaptive genetic algorithm has been proposed by encoding the chromosomal mode. They improved genetic algorithm by adjusting the encoding parameters. The experiments also indicated that the improved genetic algorithm DRSP-GA could obtain the better solutions which adapt to new transportation rapidly in global optimization than A* algorithm and Dijkstra algorithm in the shortest path problem. In this paper [8], the author presents a new genetic algorithm approach to solve the shortest path problem for road map which is based on the analogy of finding the shortest possible distance between two towns or cities in a graph or a map with potential connection, which means that the path distances are always positive. The algorithm has been tested for a road map containing more than 125 cities and the experimental results guarantee to provide acceptably good solutions for the given search space. In [9], a Genetic Algorithm (GA) approach applied on a route guidance system for finding the shortest driving time has been proposed. A different gene search approach on crossover operation named first match-genes‖ has been introduced. A mobile application for the traffic network of Ankara and the performance of the genetic algorithm tested on networks with 10, 50, 250, 1000 nodes was presented. Results obtained from experiments shows that a route guidance system that computes the shortest driving time considering the real-time traffic information can be designed using GA for handheld devices produced with limited processor and memory capacities A geographic information system (GIS) has an important role in road network analysis. In this paper [10], to calculate the shortest path the Bellman-ford algorithm and the Dijkstra shortest path algorithm was compared. Both the algorithms were used to calculate the shortest path from a source to the destination in a city. After comparison it was proved that the Bellman-Ford algorithm takes more time and more space than the Dijkstra algorithm. So it was concluded that Dijkstra algorithm is better for implementing in GIS application rather than the Bellman-ford algorithm. The paper [11] proposed a new modified algorithm for calculating the shortest path in road network. The algorithm was developed by considering the different problems that are present in the existed Dijkstra algorithm which is termed as Modified Dijkstra algorithm (MDSP). In this algorithm multiple parameters are included instead of single parameter to find a valid shortest path on a road network. This modified analyzed the shortest path by measuring its nodes and Time complexity. For evaluation the proposed algorithm is tested on a road network along with the Dijkstra algorithm (DKA), Dijkstra algorithm with buckets (DKB) and Dijkstra algorithm with double buckets (DKD). After comparison between the MDSP, DKA, DKB and DKD algorithms it was found that the MDSP takes minimum number nodes than other three algorithms and efficiently finds the shortest path for a road network with minimum complexity. In this paper [12],the authors have implemented the Particle Swarm Optimization algorithm in a wireless sensor network consisting of 10 gateways where at the time of sending of data packets from the source node to the base stations the sensor node selects a gateway in such a way that the data packets should reach to the base stations by consuming less time and less energy.

PROBLEM STATEMENT

Wireless Sensor Networks(WSNs) have become an emerging trends of the modern communication system. AWSN consists of a large number of tiny and low power sensor nodes, which are randomly or manually deployed across an unattended target area. Routing plays a vital role in the design of WSNs. Energy awareness is one of the vital parameters as the batteries used in sensor nodes cannot be recharged often. Energy can be preserved if we go for shortest path routing.

Consider a set of m sensor nodes, a set of n gateways, m >> n and a base station. A sensor node selects a gateway to transfer the data into the base station. Note that the gateway is selected among a set of reachable gateways, which is based on the load of the gateways. Finally, a gateway transfers the collected data from various sensor nodes to the base station. Therefore, the problem is two-fold.

1. Design of a load balancing algorithm to equally distribute the loads of the sensor nodes to the gateways.
2. Design of a routing algorithm to transfer the collected data of gateways to the base station.

We propose to design a shortest path routing Algorithm using Particle Swarm Optimization for Wireless Sensor Network on which if we send the data packets it will take less time, less energy so that the battery utilization will be minimized.

A. METHODOLOGY

Particle Swarm Optimization (PSO) is an optimization technique introduced by Kennedy and Eberhart in 1995 inspired by social behaviour of birds flocking or fish schooling. In PSO, each single solution is a "bird" in the search space which we call it "particle". All of particles have fitness values which are evaluated by the fitness function to be optimized, and have velocities which direct the flying of the particles. The particles fly through the problem space by following the current optimum particles as shown in Fig.1. PSO is initialized with a group of random particles (solutions) and then searches for optima by updating generations. At each iteration, each particle is updated by the following two "best" values. The first one is the best solution (fitness) it has achieved so far. This is called *pbest*. Another best value that is tracked by the particle swarm optimizer is the best value obtained so far by any particle in the population. This best value is a global best and called *gbest*. When a particle takes part of the population as its topological neighbours, the best value is a local best and is called *lbest*. After finding the two best values, the particle updates its velocity and positions .

The formulas of PSO algorithm are as follows:[13,14]

$$v_{id}^{t+1} = v_{id}^{t} + c1.rand(0,1).(p_{id}^{t} - x_{id}^{t}) + c2.rand(0,1).(p_{gd}^{t} - x_{id}^{t}) \quad (1)$$

$$x_{id}^{t+1} = x_{id}^{t} + v_{id}^{t+1} \quad (2)$$

Where v_{id}^{t} and x_{id}^{t} are particle velocity and particle position respectively. *d* is the dimension in the search space, *i* is the particle index, and *t* is the iteration number. c_1 and c_2 represent the speed, regulating the length when flying towards the most optimal particles of the whole swarm and the most optimal individual particle. p_i is the best position achieved so far by particle *i* and p_g is the best position found by the neighbours of particle *i*. *rand*(0,1) is the random values between 0 and 1. The exploration happens if either or both of the differences between the particle's best (p_{id}^{t}) and previous particle's position (x_{id}^{t}), and between population's all-time best (p_{gd}^{t}) and previous particle's position (x_{id}^{t}) are large, and exploitation occurs when these values are both small.

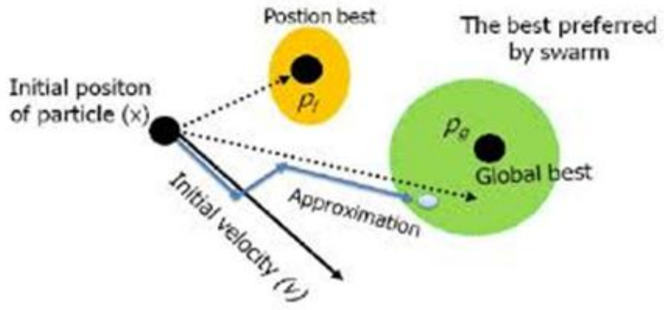

Figure 1. Particles movement

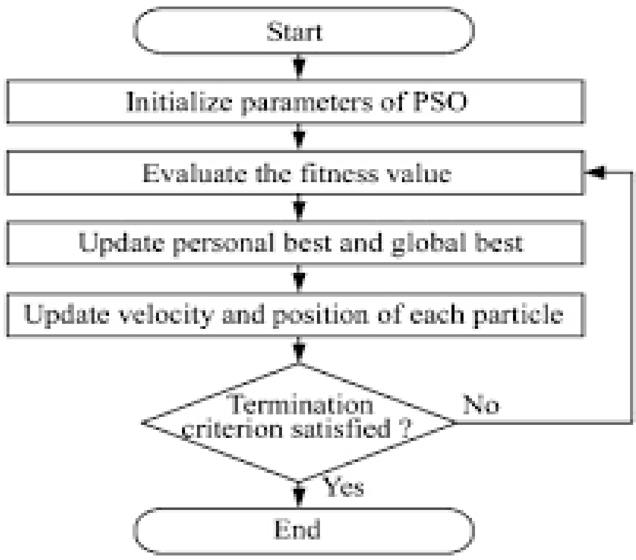

Figure 2. Flowchart of the PSO algorithm

CONCLUSION AND FUTURE WORK

From the literature survey, we see that many shortest path algorithms have been developed and has been used for many different applications. WSNs have potential applications in environment monitoring, disaster warning systems, health care, defense reconnaissance, and surveillance systems. However, the main constraint of the WSNs is the limited power sources of the sensor nodes. Therefore, energy conservation of the sensor nodes is the most challenging issue for the long run operation of WSNs. So we need to go for shortest Path routing for conserving the battery power. So we propose to implement the above Particle Swarm optimization algorithm using MATLAB as the programming language and WINDOWS Operating system to find the Shortest path in a Wireless Sensor Network. We further would go for a performance evaluation in terms of energy consumption to compare our new algorithm with the other already developed algorithms of WSN.

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