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A Modified transmission Algorithm for Resolving Vehicle Routing Problem by Intelligent Water drop Algorithm

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***Abstract*—**A comparison between two technologies 'Swarm Intelligence' and 'Intelligent Water drops' inorder to overcome the disadvantages of various technologies is an integral concern of this paper . It is nature inspired. IWD algorithm is used to calculate the solutions of the n-queen puzzle with a simple local heuristic. Water of the ocean river easily finds best way from the number of various ways available to reach from its starting to end point. The water drops that flows in rivers has optimal paths that have been obtained by the actions and reactions. With the help of modified IWD algorithm the traveling of salesman problem has also solved. So it is considered as NP-hard Polynomial.NP-hard (Non-deterministic Polynomial-time hard) is a class of problems that are informally," at least as hard as the hardest problems in NP". IWD is a fastest algorithm. It provides the minimum distance among the all options. Due to the collaboration of SI and IWD, this algorithm is more efficient. It includes the properties of both SI and IWD. This paper proposes IWD techniques to solve VRP.

Keywords: *Vehicle Routing Problem, Dynamic Vehicle Routing Problem, Ant Colony Optimization Intelligent Water drops, Swarm Intelligence.*

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I. INTRODUCTION

The Vehicle Routing Problem (VRP) is a combinatorial optimization seeking to service a number of customers with a fleet of vehicles proposed by Dantzig and Ramser in 1959. Vehicle routing problem deals with the management of pick up and/or delivery activities. Vehicle routing defines the routes & possibly the schedule for the available vehicles. Vehicle routing problem (VRP) aims to identify the number of routes for various vehicles from the departure of customers to return back from starting point, considering the all constraints in account.IWD can solve the same problem in more efficient way.

Ant colony optimization is an old technique that provides limited number of updations. It is the technique at the time of Swarm Intelligence, that time it acts as optimizer. IWD provides more updating as compare to ACO algorithm. IWD generates the paths randomly because of more updations. IWD algorithm is inspired by intelligent movement of water drops in rivers, lakes and seas. Drops intelligence is more obvious in rivers as they find their way toward the lakes, seas and oceans despite obstacles on their way. IWD is a population-based meta-heuristic algorithm introduced by Shah-Hussein in 2007.[3,8]

Vehicle Routing Problem (VRP)

The Vehicle Routing Problem (VRP) is an important because it provides efficient technique for decreasing working cost of the distribution network. Due to the time response requirement and VRP variant, this technique has a limited size. Latest research includes approximation algorithm that provide good quality solution covering all VRP constraints.

The Vehicle Routing Problem (VRP) is used to design an optimal route for a fleet of vehicles [7]. The VRP is used in supply chain management in the physical delivery of goods and services. There are several variants to the VRP. VRP is an important problem in the fields of transportation, distribution and logistics. The VRP is of the NP-hard type. The vehicle routing problem (VRP), a well-known combinatorial optimization problem, holds a central Place in logistics management. In previous papers ant-weight strategy and a mutation operation are used to solve VRP. IWD can solve the same problem in more efficient way because of it includes the properties of both Swarm Intelligence (SI) and Intelligent Water Drop (IWD).[1,3]

The VRP was first stated that was about the routing of a fleet of gasoline delivery trucks between a bulk terminal and a number of service stations supplied by the terminal. The distance between any two locations is given and a demand for a given product is specified for the service stations. Fig 1. Shows the various routes to reach the end points.

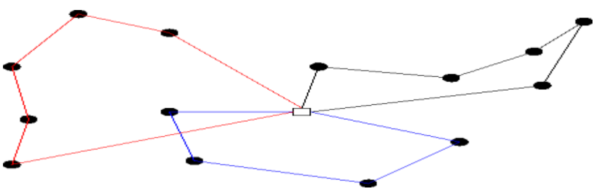

Fig. 1 vehicle routing problem

The VRP can be defined as the problem of designing least cost delivery routes from a point to a set of geographically dispersed locations (customers) considering to a set of constraints.

Dynamic Vehicle Routing Problem (DVRP), some- times referred to as On-line Vehicle Routing Problems, have recently arisen due to the advances in information and communication technologies that enable information to be obtained and processed in real-time.

In DVRP, some of the orders are known in advance before the start of the working day, but as the day progresses, new orders arrive and the system has to incorporate them into an evolving schedule. The existence of a communication system between the dispatcher (where the tours are calculated, e.g. headquarter of the company) and the drivers is assumed. The dispatcher can periodically communicate to the drivers about the new visits assigned to them. In this way, during the day, each driver always has knowledge about the next customers assigned to him/her.

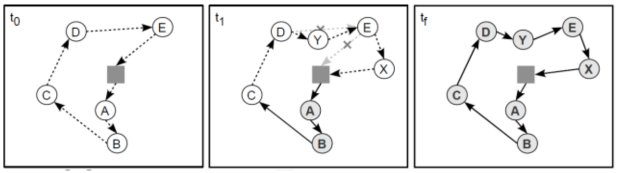

Fig. 2 Examples of dynamic vehicle routing problem

Fig 2. Illustrates the route execution of single vehicle D-VRP. Before the vehicles leaves the depot(time t_o),an initial route plans to visit the currently known requests(A,B,C,D,E).While the vehicle executes its routes, the new request (X,Y) appear at time t_1 and initial route is adjusted to fulfill them. Finally time tf the executed route is (A, B, C, D, Y, E, X)

Intelligent Water Drop Algorithm

Intelligent Water Drops algorithm (IWD) is a technique that gives shortest path to reach its ending point. A flowing water river easily selects the shortest path among the various path to reach the end point. These paths are decided on the basis of customers carrying capacity as this is done in flowing water. In natural flowing water, the water carries the soil with it. IWD swarm based Nature-inspired optimization algorithm [5]. 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 is generally a constructive population-based optimization algorithm.

The Intelligent Water Drop, IWD for short has two important factors effecting IWD:
1. The amount of the soil (no. of customers) it carries now, Soil (IWD).
2. The speed with it is moving now, Velocity (IWD).

This environment depends on the problem at hand. In an environment, there are usually lots of paths from a given source to a desired destination, which the position of the destination may be known or unknown. If we know the position of the destination, the goal is to find the best (often the shortest) path from the source to the destination. In some cases, in which the destination is unknown, the goal is to find the optimum destination in terms of cost or any suitable measure for the problem.

Water drops moving in the streams can find an optimum path considering the conditions of its surroundings to reach to its ultimate goal which is often a lake or sea. In the process of reaching the destination, water drops change the environment and consequently the environment shapes the flowing path of the drops. In other words, water drops can change the river beds in which they are flowing, but the environment can also influence the moving directions of the water drops. The sole energy in this process is the gravitational force.
The IWD algorithm has two kinds of parameters namely static and dynamic parameters. Static parameters are those that remain constant during the lifetime of the IWD algorithm. Dynamic parameters are those that vary after each iteration.

It considers an IWD moving in discrete finite-length steps.
From its current location to its next location, the IWD velocity is increased by the amount nonlinearly proportional to the inverse of the soil between the two locations. Moreover, the IWDs soil is increased by removing some soil of the path joining the two locations. The amount of soil added to the IWD is inversely (and nonlinearly) proportional to the time needed for the IWD to pass from its current location to the next location. This duration of time is calculated by the simple laws of physics for linear motion. Thus, the time taken is proportional to the velocity of the IWD and inversely proportional to the distance between the two locations. Another mechanism that exists in the behavior of an IWD is that it prefers the paths with low soils on its beds to the paths with higher soils on its beds. To implement this behavior of path choosing, we use a uniform random distribution among the soils of the available paths such that the probability of the next path to choose is inversely proportional to the soils of the available paths. The Lower the soil of the path, the more chance it has for being selected by the IWD.

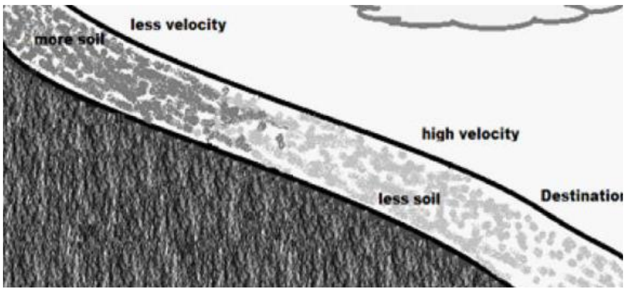

Fig.3

Swarm Intelligence (SI)

It is the collective behavior of decentralized, self-organized systems, natural or artificial. The concept is employed in work on artificial intelligence. The IWD algorithm may fall into the category of Swarm intelligence and Met heuristic. Three special operators for discrete optimization problem named swap, shift and symmetry transformations are presented [11]. Convergence analysis and time complexity of the algorithm are also considered. To make the algorithm simple and efficient, no parameter adjusting is suggested in current version. Experiments are carried out to test the performance of the strategy, and comparisons with simulated annealing and ant colony optimization have demonstrated the effectiveness of the proposed algorithm. The results also show that the discrete state transition algorithm consumes much less time and has better search ability than its counterparts, which indicates that state transition algorithm is with strong adaptability. In discrete version of state transition algorithm, three special state transition operators are designed to manipulate the permutation. A simplest but much efficient parameters control strategy is proposed, in which, no parameters of the operators need adjusting. Some experiments are done to evaluate the proposed algorithm, and the results show that the discrete version of STA has much better performance not only in the search ability but also in the time consuming.

II. Related Work

Various techniques have been proposed to reduce the problem of vehicle routing:

Russell Bent ,Pascal Van Hentenryck, August 2002[2],"A Two stage Hybrid Local Search for the Vehicle Routing Problem with Time Windows "The vehicle routing problem with time windows is a hard combinatorial optimization problem that has received considerable attention in a last decades. This paper proposes a two stage hybrid algorithm for this transportation problem. This algorithm first minimizes the number of vehicles, using simulated annealing. It then minimizes travel cost by using a large neighborhood search that may relocate a large number of customers, Experimental results demonstrate the effectiveness of the algorithm, which has improved 10(17%)of the 56 best published solution to the solomon benchmarks, while matching or improving the best solutions in 46problems(82%). More important perhaps, the algorithm is shown to be very robust .With a fixed configuration of its parameters, it returns either the best published solutions or solutions very close in quality on all solomon benchmarks.

Abdul Kadar Muhammad Masum, Md. Faisal Faruque, Mohammad Shahjalal, Md. Iqbal Hasan Sarker,7, 2011."Solving the Vehicle Routing Problem using Genetic Algorithm" [4]. The main goal of this research is to find a solution of vehicle routing problem using genetic algorithm. The vehicle routing problem is a complex combinatorial optimization problem that belongs to the NP-complete class. Due to the nature of the problem it is not possible to use exact methods for large instances of the vehicle routing problem .GA provide a search technique used in computing to find true or **approximate** solution to optimization and search problems. However we use some heuristic in addition during crossover or mutation for tuning the system to obtain better results.

Suresh Nanda Kumar, Ramasamy Panneerselvam March 12, 2012. "A Survey on the Vehicle Routing Problem and Its Variants"[6]. In this paper it has conducted a literature on the recent developments and publications involving the vehicle routing problem and its variants, namely vehicle routing problem with time windows (VRPTW) and the capacitated vehicle routing problem (CVRP) and also their variants. The VRP is classified as an NP-hard problem. Hence, the use of exact optimization methods may be difficult to solve these problems in acceptable CPU times, when the problem involves real-world data sets that are very large. The vehicle routing problem comes under combinatorial problem. Hence to get solutions in determining routes which are realistic and very close to the optimal solution, we use heuristics and meta-heuristics. In this paper we discuss the various exact methods and heuristics and meta-heuristics used to solve the VRP and its variants.

C. Archetti, M.G. Speranza, D. Vigo, 2013."Vehicle Routing Problems with Profits"[10]: This paper is a survey of the broad class of vehicle routing problem with profits. In routing problems with profits, a profit is associated with each customer and, contrary to what happen in the classical routing problem, the subset of customer to be served is chosen. The decision is made on the basis of an objective function that includes the collected profit and/or the travel cost. We review the literature on this class of problems focusing on the distinction between single vehicle and multiple vehicle problems.

III. Intelligent Water Drops Algorithm

IWD is a population-based meta-heuristic algorithm introduced by Shah-Hussein in 2007. 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 is generally a constructive population-based optimization algorithm. Water of the ocean river easily finds best way from the number of various ways available to reach from its starting to end point. The water drops that flows in rivers has optimal paths that have been obtained by the actions and reactions. With the help of modified IWD algorithm the traveling of salesman problem has also solved.

Intelligent Water Drops Algorithm working procedure

IWD works based on the following steps.[9]

1. Initialize static parameters and dynamic parameters: Static parameters:

For velocity updating, parameters are av =1, bv = 0.01, cv = 1

For soil updating, parameters are as = 1, bs = 0.01, cs =1. InitSoil = 10000 and InitVel = 200.

Dynamic parameters:

Visited node list of each IWD, vc(IWD) is set as empty initially.

2. Repeat steps 2.1 to 2.4 for each IWD.

2.1 IWD chooses the next node based on probability

$$p(i,j) = f(soil(i,j)) \,/\, \Sigma k \notin vc \;\; f(soil(i,j)) \qquad (1)$$

Such that,

$$f\; soil(i,j) = 1 \,/\, \in s + g(soil(i,j))$$

And

$$\left\{ g\; soil(i,j) = \quad soil(i,j) \right.$$

if min $soil\ i,j > 0 = \quad soil(\ i,j) - \min soil(\ i,j)$
$elsewhere 1 \notin vc(IWD)$

2.2 Update the velocity of IWD after it moves from node $(i$ to $j)$

$$vel(\ t+1) = vel(\ t) + av/bv+cv\ .\ soil(\ i,j) \qquad (2)$$

2.3 Compute the soil that IWD taken from the path it travels, Δsoil (i,j)

$$\Delta soil(\ i,j) = as/bs+cstime2(i,j;vel(\ t+1\ )) \qquad (3)$$

Such that, $time(\ i,j;vel\ (t+1)) = HUD(j)/vel(t+1)$

where HUD (j) is the distance from the current node to the next node .

2.4 Update the soil in the path where the IWD is traversed using,

$$soil(\ i,j) = (\ 1-\rho n)\ .soil(\ i,j) - \rho n.\Delta soil(\ i,j) \qquad (4)$$

$$So\ soil^{IWD}\ {}^{2} = \ soil^{IWD} + \Delta soil\ (i,j)$$

3. Find the iteration best solution among all the solutions.

4. Update the soils on the paths where the iteration best solution is found by,

$$soil(\ i,j) = (1-\rho IWD)\ .soil(\ i,j) - \rho IWD.1/(NIB-1).\ soil^{IWD} \qquad (5)$$

Where, NIB is the number of nodes in the solution.

5. Increment the iteration and go to step 2 until the maximum number of iteration is reached.

Importance of Intelligent Water Drops Algorithm

The following three reasons provide the necessity and importance of the IWD algorithm:

- It provides good quality solutions using average values.
- IWD algorithm has fast convergence when compared to other methods.
- It is also flexible in the dynamic environment.

IWD algorithm is applicable for more applications such as Vehicle Routing, Robot path planning, Travelling Salesman Problem.

Flow chart of IWD algorithm

Fig 4 is Flow Chart that follows the steps to calculate the shortest path for vehicles to reach destination .The IWD algorithm is generally a population-based optimization algorithm. Intelligent Water Drops algorithm (IWD) is a technique that gives shortest path to reach its ending point. A flowing water river easily selects the shortest path among the various path to reach the end point. These paths are decided on the basis of customer's carrying capacity as this is done in flowing water. IWD is a fastest algorithm. It provides the minimum distance among the all options. Due to the collaboration of Swarm Intelligence and Intelligent WaterDrop algorithm, this algorithm is more efficient.It provides the concept of updating the population using SI and selection at the best velocity population.

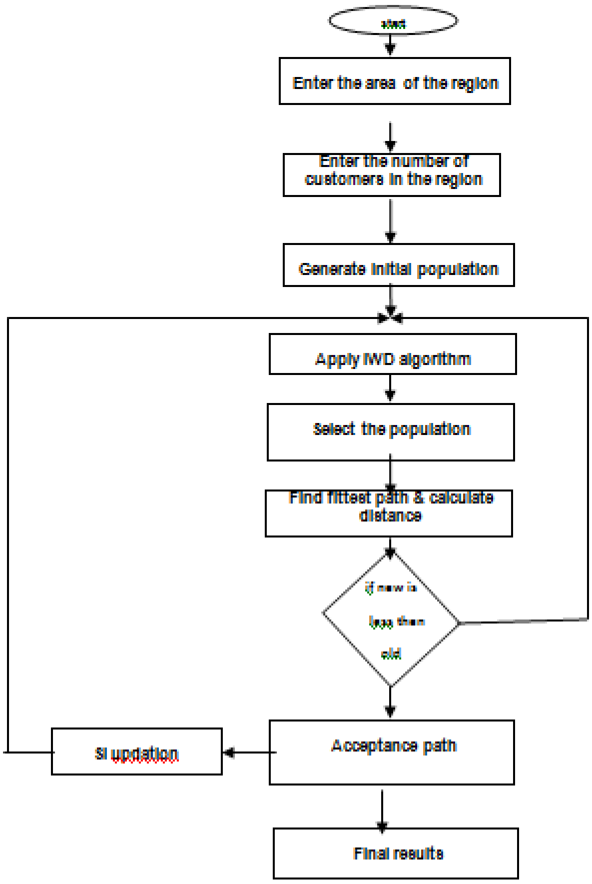

Fig. 4 Composition of IWD

IV. Objectives and Problem Formulation

VRP is an important optimization problem in the field of transportation, distribution and logistics. To date, several exact and approximate approaches have been proposed to solve VRP. So here, we apply a population based optimization algorithm to VRP by imitating the natural flow of water drops. The "Intelligent Water Drops" or IWD algorithm which solves the VRP by modeling water drops. The vehicle routing problem as encountered in practice involves many restrictions on the routes that delivery vehicles can follow (e.g. a limit on the number of hours that a driver can work) and we consider some of the more common problems below. We can classify these restrictions to a certain extent as relating either to the vehicles or to the customers. Each vehicle has a limit (capacity - usually weight and/or volume) on the goods carried, e.g. tankers delivering to petrol (gasoline) stations are volume limited, buses have a limit on the number of people legally allowed on board, etc.

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Each vehicle has a total working time from departure to arrival back at the depot; typically to comply with legal restrictions on driver working hours. Each vehicle has a time period within which it must leave the depot, typically to ensure that space is available for incoming vehicles to resupply the depot.

1. To implement an optimization algorithm to achieve maximum customer coverage in minimum distance thus main objective is:
    a. Minimum distance.
    b. Maximum customer coverage.
2. To mix IWD optimization algorithm with SI to update data.
3. To introduce IWD optimization algorithm.
4. To do analysis with the previous system

V. Experimental Results

Mat lab version 7.10.0.499(R2010a) is used to provide the grouping of the customers and to select the best path to reach the end point. Fig. 5 shows the grouping of the 40 customers. In grouping the customers are assigned to the adjacent end point. So that the distance travelled by the vehicle is shorter. The customers are clustered based on the minimum distance between customers and end points. Distance between the customer and the end point is computed and based on the minimum distance customers are grouped and the results are shown[6] .

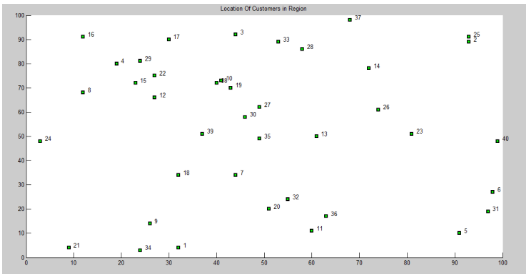

Fig.5 Location of 40 customers in xy coordinate

Fig 6 shows the various routes of 40 customers. In routing the customers, in each group are divided into different routes. The aim of routing is to minimize the number of routes or vehicles used.and result is shown.

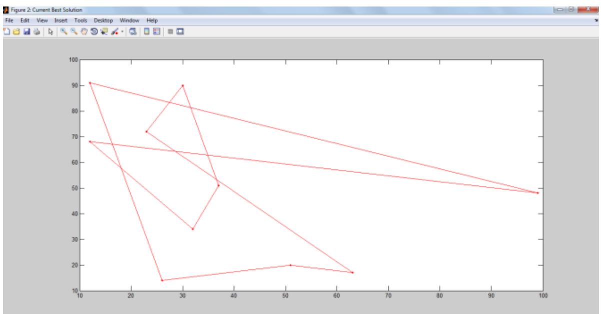

Fig.6 Best routes for above shown 40 customers

Fig. 7 and fig .8 describes the second experiment with the total number of 80 customers grouping and finding the shortest and the best path to reach the end point.

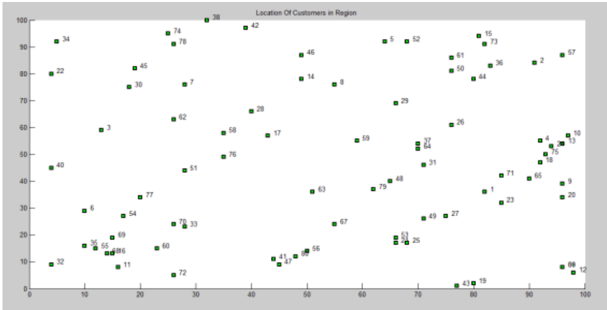

Fig.7 Location of 80 customers in xy coordinates

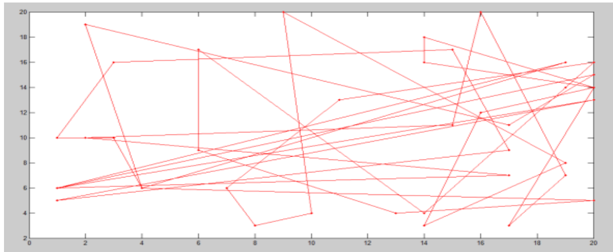

Fig.8 Best routes for above shown 80 customers

VI. Conclusion and Future Scope

In this it has concluded that "**The Vehicle Routing Problem**" (VRP) is an optimization problem, seeking to serve a number of customers with a fleet of available vehicles. So it has implemented optimization algorithm to achieve minimum distance and maximum customer coverage thus it has introduced IWD optimization algorithm. Though it has mixed IWD optimization with SI to update data and then this has analyzed it with the previous system which leads to maximum customer coverage with less distance coverage and fast algorithm. The Future scope of using this algorithm in vehicle routing problem is that we can implement the same problem with the real time data and more objectives except distance and time .

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