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Review of Various Variants of ACO for Solid Waste Management

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Abstract— The present work utilizes Multi-Objective Ant Colony Optimization technique for the generation of optimal route for Solid Waste Management. The present algorithm is based on ant's behaviour, pheromone update & pheromone evaporation and is used to enhance the local search. This procedure is applied to propose a method for solid waste routing to effectively handle Solid Waste. Our technique is based on the various variants of ACO. The objective of this review paper is to study the various variants of ACO for Solid Waste Management.

Keywords - Multi-Objective Ant Colony Optimization, Solid Waste, Solid Waste Management (SWM), Variants of Ant Colony Optimization (ACO), Optimal Route

I. INTRODUCTION

The collection of municipal solid waste is one of the most tedious operational problems faced by local authorities in any city. In last few years, due to a number of environmental health and cost concerns, many municipalities, particularly in industrialized nations, have been forced to evaluate their solid waste management and examine its environmental impacts and cost effectiveness, in terms of designing collection routes. During the last 15 years, there have been new developments, promiscuous technological advances, and mergers and acquisitions in the waste industry. The outcome is that both private and municipal haulers are giving serious consideration to new technologies such as computerized vehicle solutions

A. What is solid waste?

Solid waste generally exists in two forms, one is garbage which comes under Bio-degradable waste and the other one is rubbish which comes under Non-bio degradable waste. Garbage is basically a mixture of kitchen waste coming from house hold and rubbish is the mixture of all type of waste like paper, glass, plastic etc. Solid waste generated in daily life can overcome only by three ways Reduce, Reuse and Recycle i.e.3'R Principals if we follow proper methods of disposal of the waste. Since the beginning, mankind has been generating waste, be it bones and the other parts of animals we slaughter for food or the wood we cut to make carts, etc. With the progress of civilization, the waste generated became of a complicated nature. At the end of the 19th century, the industrial revolution saw the growth of world of consumers. 1.3 Types of Solid Waste. Depending on their source it can be classified into three different types:

- Household waste is generally classified as municipal waste
- Industrial waste as hazardous waste
- Biomedical waste as infectious waste

1) *Municipal solid waste:* Municipal solid waste consists of household waste, sanitation residue ,waste from streets and construction and demolition debris, . This waste is generated mainly from residential and commercial complexes. With rising urbanization and changing food habits and lifestyle, the amount of municipal solid waste has been increasing rapidly and its composition is changing continuously. In 1947, as estimated 6 million tonnes of solid waste was generated in cities and towns of India. In 1997 it was near about 48 million tonnes. More than 25% of the municipal solid waste is not collected at all; 70% of the Indian cities lack adequate capacity to transport it and there are no sanitary landfills for disposal of waste. The existing landfills are neither well managed nor well equipped and are not lined properly to protect against contamination of soil and ground water. During the last few years, the consumer market has grown rapidly leading to products being packed in aluminium foils, plastics, cans, and other non biodegradable items that cause countless harm to the environment. The use of plastics have been banned by some municipal areas in India and they seem to have achieved success. Ladakh is one of the example where the local authorities imposed a ban on plastics in 1998 and today one will not see a single piece of plastic in the entire district of Ladakh. Other states should follow the example of this region and ban the use of items that cause harm to the environment. One positive note is that in several large cities, shops have begun packing items in biodegradable or reusable bags.
2) *Hazardous waste:* Industrial and hospital waste is considered as hazardous because they contain toxic substances. Some types of household waste are also hazardous. Hazardous wastes can be highly toxic to humans, plants and animals; and are corrosive, highly inflammable, and explosive and react when exposed to certain things like gases. Around 7 million tonnes of hazardous wastes is generated in India every year, most of which is concentrated in three

states: Tamil Nadu, Andhra Pradesh and Uttar Pradesh. Shoe polish, old batteries, paint tins, old medicines and medicine bottles are some of the household wastes that can be categorized as hazardous waste. In the industrial sector, hazardous waste is mainly generated by the metal, chemical, paper, pesticide, dye, refining, and rubber goods industries.

3) *Hospital waste:* Hospital waste is generated during the diagnosis, treatment, and immunization of human beings, animals and in research activities in these fields, also in the production or testing of biological. It includes waste like soiled waste, sharps, disposables, chemical waste, anatomical waste, discarded medicines, etc. These are in the form of disposable syringes, bandages, human excreta, body fluids, etc. This waste is highly infectious and can be a serious threat to human health if not managed in a discriminate and scientific manner. It has been estimated roughly that at least 1 kg of the 4 kg of waste generated in a hospital would be infected. Hospital waste contaminated by chemicals is also considered hazardous. These chemicals include phenols and formaldehyde, which are used as disinfectants, and mercury, which is used in equipment that measure blood pressure or thermometers in India Most hospitals do not have proper disposal facilities for these hazardous wastes.

B. Impacts

When the waste is dumped, because of its composition it does not decompose very quickly, making space unavailable for other waste. Given below are some examples to understand how much time it takes for various materials to decompose.

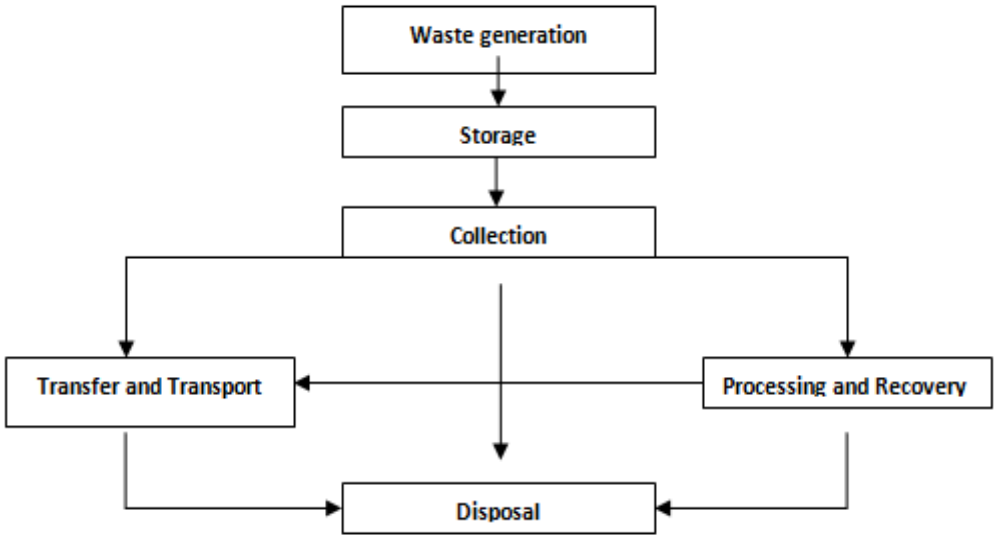
TABLE I APPROXIMATE TIME TAKEN BY THE LITTER TO DEGENERATE

Types of litter	**Approximate time taken by the litter to degenerate**
Organic waste like leftover foodstuff, vegetable and fruits peel, etc.	1-2 week
Paper	10-30 days
Cotton cloth	2-5 months
Wood	10-15 years
Woolen items	1 year
Aluminum, Tin, and other metal items like cans	100-500 years
Plastic bags	One million years
Glass bottles	Undetermined

Unmanaged heaps of waste causes numerous adverse impacts to the human health as well as environment. Waste is a serious health hazard which leads to the spread of infectious diseases. Unattended waste lying around attracts rats, flies, and other creatures who in turn spread diseases. Air pollution is another factor to be considered. Generally, it is the wet waste that decomposes and releases a bad odour which leads to unhygienic conditions and thereby cause rise in the health problems. Also, co-disposal of residential/industrial hazardous waste with municipal waste can expose people to chemical and radioactive hazards. Uncollected solid waste can also inhibit storm water runoff therefore resulting in the formation of stagnant water bodies that become the breeding ground for disease causing agents. Wastes dumped alongside roads, riverbanks, seas, lakes and abandoned quarries, results in the inevitable effect of contaminating water supplies as well as the whole aquatic chain. Animals grazing on dumps can pass on diseases via the food chain.

C. Collection of MSW broadly involves following functional elements

FLOW CHART I FLOW CHART OF THE FUNCTIONAL ELEMENTS



Stage I: Collection of Waste from a Non point Source: This stage includes door-to-door collection of waste. Mostly collection is done by garbage collectors who are employees under contract to the government. Garbage collectors employed under local governing bodies collect the waste manually generated at the household level and dump that in the community bins at specified street corners. Municipality is not responsible for door to door collection of waste from houses, small shops, offices, and small markets. Here people are required to deposit their wastes in community bins (stationary or haul types), from where it is collected by municipal crew. The vehicle used in this stage for collection, is simple and small & varies from place to place. It may be two-wheeler cart pulled by an individual or bell ringing vehicles.

Stage II: Collection from Point Source: Waste collected from non point source is deposited to definite point sources i.e. communal bins Communal bins are placed in apartment complexes, near markets, and in other appropriate locations like hotels, shopping complex, public places like gardens, religious places are other definite point sources. Vehicles collects waste from these point sources and then transport it to transfer stations and disposal sites whichever is near. Manually or mechanically loaded compactors are often used in this stage. Placing communal bins at appropriate locations for storage of waste is important to manage waste properly. For better MSW management garbage should be lifted frequently from these point sources. Frequency in lifting garbage from these points really matters otherwise garbage pile will create other problems. It is challenging task particularly in metros.

Stage III: Transportation to Disposal sites: Transfer refers to the movement of waste or materials from collection points to disposal sites. Depending on the distance to be covered, transportation of waste from collection point to disposal sites is carried out by using different types of vehicles. Larger vehicles carry the waste from the collection points to the disposal sites whereas small vehicles discharge waste at transfer stations from where the wastes are loaded into larger vehicles for transportation to the disposal sites. Transfer stations are located at different places In metro cities to support intermediate transfer of waste from the surrounding areas to the dumping grounds. Transfer stations are centralized facilities where waste is unloaded from smaller collection vehicles and re-loaded into larger vehicles so that it can be transferred to a disposal or processing site. The transportation of garbage from the transfer stations is done generally using Bulk Refuse Carriers and Trailers. In large cities, covered trucks, open flatbed trucks, and some compactors are in use, whereas in smaller cities tricycles, tractor-trailers, and animal carts are common. Study shows that in metros like Mumbai, Delhi around 60 per cent of waste is transported through mobile compactors and closed tempos; 10 per cent is through partially open dumpers whereas 20 per cent is through tarpaulin covered vehicles, which includes debris and silts.

II. RELATED STUDY

"Er.Lavina Maheshwari, Er. Pankaj Kumar" This paper presents Rank based Ant colony optimization Algorithm to find the best routing for collecting solid waste in cities. The system tries to implement the solid waste management routing problem using Ant colony optimization. In this research the problem of routing in solid waste management is the main point of focus in thesis. Three categories of ACO algorithms have been described and tested here i.e. ant system algorithm, min-max system and the rank based system. Rank based Ant colony results compared with the Ant system algorithm, Min-Max system. The results were compared by varying the number of trails, number of ants and number of tours. Three main factors were studied in each of the case i.e. average best tour, average number of iterations and average best time. The average best tour and average best time was found worst in case of rank based system and average number of iteration is less than the ant system and min-max system. On the basis of average number of iteration, it was found that the rank based system is found better in overall situation.

"Ansari Muqueet Husain, Shaikh Mohammad Sohail, V. S. Narwane" proposed work utilizes Ant Colony Optimization (ACO) technique for the generation of optimal motion planning sequence. The present algorithm is based on ant's behavior, pheromone update & pheromone evaporation and is used to enhance the local search. This procedure is applied for proposing a method for path planning of mobile robot motion in warehouses and for materials handling with starting from any location to reach a certain goal. This technique is based on the well-known environment of the warehouse. To validate the proposed algorithm, the program has been developed in Visual C++.This technique can generate feasible, stable and optimal robotic materials handling sequence and then path sequence can satisfy the materials handling constraints with minimum travel time. The solution is either optimal or near optimal.

"Nikolaos V. Karadimas, Maria Kolokathi,Gerasimoula Defteraiou, Vassili Loumos" proposed two individual algorithmic solutions, the Ant Colony System (ACS) algorithm and the ArcGIS Network Analyst, implemented and discussed for the identification of optimal routes in the case of Municipal Solid Waste (MSW) collection. Both proposed applications are based on a geo-referenced spatial database supported by a Geographic Information System (GIS). The GIS takes into account all the required parameters for the Municipal Solid Waste Collection i.e. positions of waste bins, truck capacities, road network and the related traffic, etc and its desktop users are able to model realistic network scenarios. In this case, the simulation consists of scenarios of visiting varied waste collection spots in the Municipality of Athens. The user is able to define or modify all the required dynamic factors in both the applications, for the creation of an initial scenario, and alternative scenarios can be generated by modifying these particular parameters. Finally, the optimal solution is estimated by each routing optimization algorithm, which is followed by a comparison between these two algorithmic approaches on the newly designed collection routes.

"Marco Dorigo, and Luca Maria Gambardella" presents the ant colony system (ACS), a distributed algorithm applied to the traveling salesman problem. In the ACS, a set of cooperating agents called ants cooperate to find good solution to TSP. while building solutions ants cooperate using an indirect form of communication mediated by a pheromone they

deposit on the edges of the TSP graph.ACS is studied by performing experiments to understand its operation. The results show that the ACS outperforms other nature-inspired algorithms such as evolutionary computation and simulated annealing, and it is concluded by comparing ACS-3-opt, a version of the ACS augmented with a local search procedure, to some of the best performing algorithms for symmetric and asymmetric TSP's.

"Teemu Nuortio,Harri Niska, Jari Kytojoki, Olli Braysy" presents the optimization of vehicle routes and schedules for collecting municipal solid waste(MSW) in Eastern Finland. The solutions are generated by a recently developed guided variable neighborhood thresholding metaheuristic, adapted to solve real-life waste collection problems. Several implementation approaches are discussed to speed up the method and cut down the memory usage. A case study on the waste collection in two regions of Eastern Finland demonstrates that significant cost reductions can be obtained as compared with the current practice.

"Mr. Ankit Verma and Prof. B.K Bhonde" proposed study aims at analyzing existing status of generation, collection, storage, transportation, treatment and disposal activities of Municipal Solid Waste of Indore city. This paper portrays Geographical Information System as a decision support tool for Municipal solid waste management and it will help to get rid of solid waste as per the study area. Amendment in the system through Geographical Information System model would reduce the waste management workload to some extent and provide remedies for some of the Solid waste management problem in the case study area.

TABLE II COMPARISON OF VARIOUS TECHNIQUES

S.No.	Author	Year	Based on	Comparison with	Conclusion
1.	Er.Lavina Maheshwari,Er. Pankaj Kumar	2014	Rank Based Ant Colony Optimization	Ant system algorithm, min-max system and the rank based system.	Average best tour and Average best time is more than the min-max system and ant system. Also,average number of iteration is less than the ant system and min-max system. On the basis of average number of iteration, it was found that the rank based system is found better in overall situation.
2.	Ansari Muqueet Husain, Shaikh Mohammad Sohail, V. S. Narwane	2012	Ant Colony Optimization (ACO) technique		1.Real-time Optimization; 2. Ant based Robot Path Planning (ARPP) reduces the path cost and provides shorter computation time with smaller number of generations.
3.	Nikolaos v. Karadimas, Maria Kolokathi, Gerasimoula Defteraiou, Vassili Loumos	2007	Geo-referenced Spatial Database supported by a Geographic Information System (GIS).	ArcGIS Network Analyst and the Ant Colony System (ACS) algorithm	The tour length and eventually the total cost in time and money can be greatly minimized. ArcGIS NA is not only capable to reproduce a Satisfying number of scenarios, but also it has the ability to be easily adapted to new conditions.
4.	Marco Dorigo and Luca Maria Gambardella	1997	ACS-3-opt	Travelling Salesman Problem	1.Combination of constructive method with local search generates good starting solution which takes these solutions to a local optimum seems to be the best Strategy.

					2.ACS is also a very good constructive heuristic to provide starting solutions for local optimizers
5.	Gulab Singh, Brajesh Singh,Shubham Rathi, Saurabh Haris	2014	Shortest Path Algorithm		1. This model is applicable for any type of route network having range among positive integers. 2.This model is valid for one way, two way and also for if there is no direct link among the nodes .
6.	Teemu Nuortioa, Jari Kytojokib,Harri Niska, Olli Braysy	2005	Guided variable neighbourhood thresholding metaheuristic		The experimental results demonstrate that significant savings as compared to the current practice can be obtained in both studied levels of optimization: optimization of single routes only, and optimization of both routing and Scheduling for the whole collection period.
7.	Mr. Ankit Verma, Prof. B.K Bhonde	2014	Geographical Information System		1. Geographical Information System makes waste management planning easy, efficient and can be implemented quickly also. 2. It reduces the waste management work load to great extent.

III. CONCLUSIONS

Ant Colony Optimization (ACO) technique provides Real-time Optimization by reducing the path cost and provides shorter computation time. As Compared to the Ant System and min-max system, rank based algorithm provides better Average best tour and Average best time. Also, average number of iterations are less in case of Rank Based Algorithm. The tour length and eventually the total cost in time and money can be greatly minimized using Geo-referenced Spatial Database supported by a Geographic Information System.

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