Solid Waste Routing by Exploiting Multi-Objective Ant Colony Optimization

Rachita Sharma, Mr. Ashish Sharma

CSE DCRUST, Murthal

rachitas749@gmail.com, kaushish.ashish@gmail.com

(9996247281)

Abstract—The routing is one of the main components of solid waste management where the collection takes most of the total system cost. The paper aims to find the best route for collecting solid waste in cities. Multi-Objective Ant Colony Optimization is a new meta- heuristic technique inspired by the nature of the real ants and helps in finding the optimal solution of the problems. Our technique is based on the various variants of ACO i.e. Basic ant system, elitist ant system, rank based system, min-max system best-worst system and ant colony system. Some of the main factors studied in each of the case are average number of iterations, average best tour, and average best time. Finally, the optimal solution is estimated by each routing optimization algorithm, followed by a comparison between these algorithmic approaches on the newly designed collection routes.

Keywords— Solid waste management, Meta-heuristic Technique, Ant Colony Optimization (ACO), Multi-Objective Ant colony optimization (MOACO), Routing, Best Route, Waste collection, Variants of ACO.

INTRODUCTION

Introduction to solid waste management

Solid waste is the useless or unwanted solid materials generated from combined residential, commercial and industrial activities in a specified area. It may be categorized according to its origin (domestic, industrial, commercial, construction or institutional); according to its contents (organic material, plastic paper, glass, metal, etc); or according to hazard potential (toxic, non-toxic, radioactive, flammable, infectious etc). Management of solid waste reduces adverse impacts on the human health and environment and supports economic development and improved quality of life. A number of processes are involved in managing the waste effectively for a municipality which includes monitoring, collection, transport, processing, recycling and disposal.

Reduce, Reuse, Recycle

Methods of waste reuse, recycling and waste reduction, are the preferred options when managing waste. Many environmental benefits can be derived from the use of these methods. They reduce or prevent green house gases emission, reduce the release of pollutants, conserve resources, save energy and reduce the demand for waste treatment technology and landfill area. Therefore, it is advisable to adopt and incorporate these methods as part of the waste management plan

The management of solid waste typically involves its collection, transport, processing and recycling or disposal.
Collection includes the gathering of solid waste and recyclable materials, and the transport of these materials, after collection, to the location where the collection vehicle is emptied. This location may be a material processing facility, a transfer station or a landfill disposal site.
Waste disposal today is done primarily by land filling or closure of existing dump sites. Modern sanitary landfills are not dumps; they are engineered facilities used for disposing of solid wastes on land without creating hazards to public health or safety, such as the breeding of insects and the contamination of ground water.

Collection of MSW broadly involves following steps:

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.

Health impacts of solid waste

Solid waste management is one of the major challenges faced by many countries around the globe. Inadequate collection, recycling or treatment and uncontrolled disposal of waste in dumps can lead to severe hazards, such as health risks and environmental pollution. Some of them are discussed below:

- Organic domestic waste poses a serious threat, as they ferment, creating conditions favourable to the survival and growth of microbial pathogens. Direct handling of solid waste can result in various types of chronic and infectious diseases with the waste workers and the rag pickers being the most vulnerable.

- Exposure to hazardous waste can affect human health, and children being more vulnerable to these pollutants. In fact, direct exposure can lead to diseases through chemical exposure as the release of chemical waste into the environment leads to chemical poisoning. To establish a connection between health and hazardous waste many studies have been carried out in various parts of the world.

- Waste from industries and agriculture can also cause serious health risks. Other than this, co-disposal of municipal waste with industrial hazardous waste can expose people to chemical and radioactive hazards. Uncollected solid waste can also obstruct storm water runoff, resulting in the formation of stagnant water bodies that become the breeding ground of disease. Waste dumped near a water source also causes contamination of the water body or the ground water source. Direct Dumping of untreated waste in lakes, rivers, and seas results in the accumulation of toxic substances in the food, through the plants and animals that feed on it directly or indirectly.Disposal of hospital and other medical waste requires special attention since this can create major health hazards. This waste generated from the health care centres, hospitals, research centres and medical laboratories such as discarded swabs, syringe needles, bandages, plasters, and other types of infectious waste are often disposed with the regular non-infectious waste.

- Disposal sites and Waste treatment can also create health hazards for the neighborhood. Improperly managed and designed landfills attract all types of insects and rodents that spread disease and improperly operated incineration plants cause air pollution. Ideally these sites should be located at a safe distance from all human settlement. Landfill sites should be walled and well lined to ensure that there is no leakage into the nearby ground water sources.

 Recycling too carries health risks if proper precautions are not taken. Workers working with waste containing metals and chemicals may experience toxic exposure. Disposal of health-care wastes require special attention as it can create major health hazards, i.e. Hepatitis B and C caused by discarded syringes. Rag pickers and others involved in scavenging the waste dumps for items that can be recycled, may sustain injuries and come into direct contact with these highly infectious items.

RELATED WORK

"Er. LavinaMaheshwari, 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 theant 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 behaviour, 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.

International Journal of Engineering Research and General Science Volume 3, Issue 4, July-August, 2015
ISSN 2091-2730

PROPOSED WORK

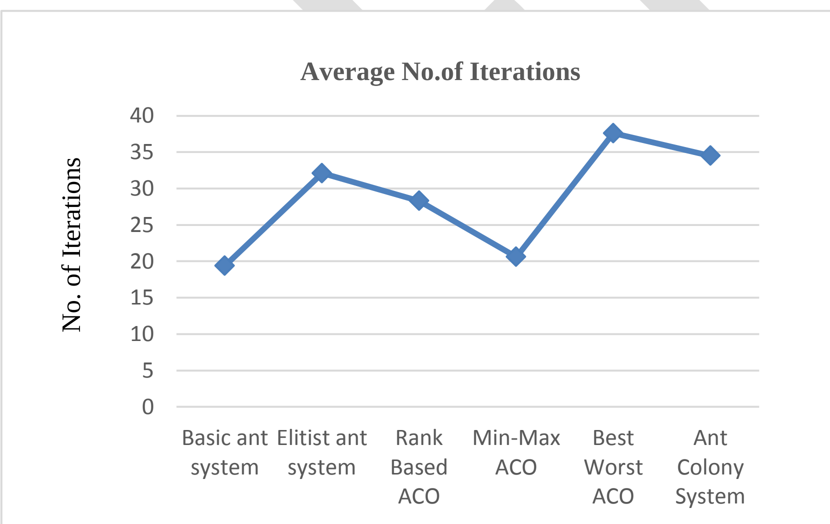
In the research we approach the problem of routing in solid waste management is the main point of focus in dissertation. There are many ways to solve the problem of solid waste management. Ant colony optimization is a new technology to solve the optimization problem. As routing in solid waste management is a challenge, so in this dissertation we are planning to tackle the routing in solid waste management through the technique of ant colony optimization. The Ant Colony Optimization (ACO) algorithm was inspired through the observation of swarm colonies and specifically ants. Ants are social insects and their behavior is focused to the colony survival rather the survival of the individual. Specifically, the way ants find their food is noteworthy. Although ants are almost blind, they build chemical trails, using a chemical substance called pheromone. The trails are used by ants to find the way to the food or back to their colony. Solid waste routing is being implemented here using multi-objective ant colony optimization. Different Variants will be used for this purpose like basic Ant System, elitist Ant System, MAX-MIN Ant System, rank based Ant System best-worst ant system. Here we will try to achieve the results by varying different parameters like the number of ants, number of trials, etc.

RESULT

1.

TABLE I

S. No.	Variants of ACO	Average No. of Iterations
1	Basic ant system	19.4
2	Elitist ant system	32.1
3	Rank Based ACO	28.3
4	Min-Max ACO	20.6
5	Best Worst ACO	37.6
6	Ant Colony System	34.5

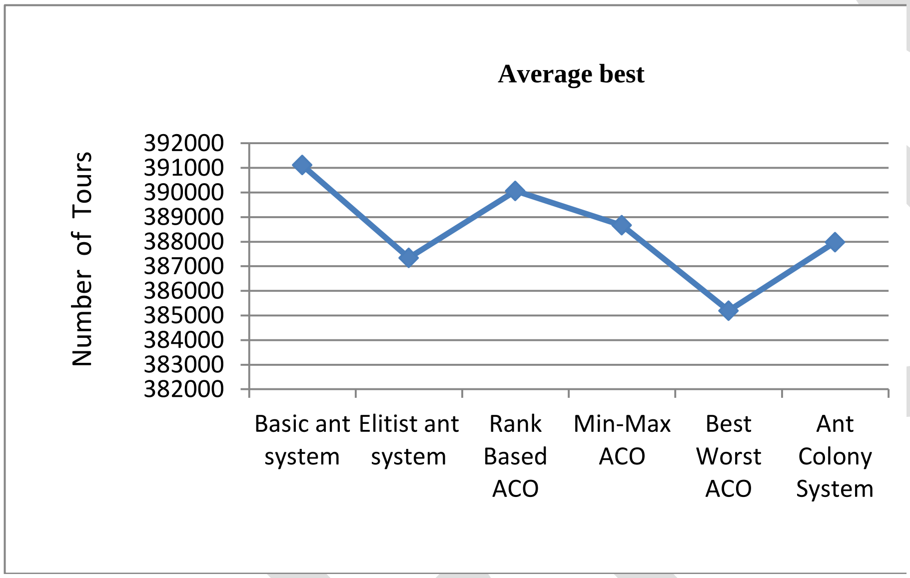


GRAPH I

2.

TABLE II

S. No	Variants of ACO	Average best
1	Basic ant system	391113.4
2	Elitist ant system	387338.5
3	Rank Based ACO	390061.1
4	Min-Max ACO	388661
5	Best Worst ACO	385195.2
6	Ant Colony System	387980.8

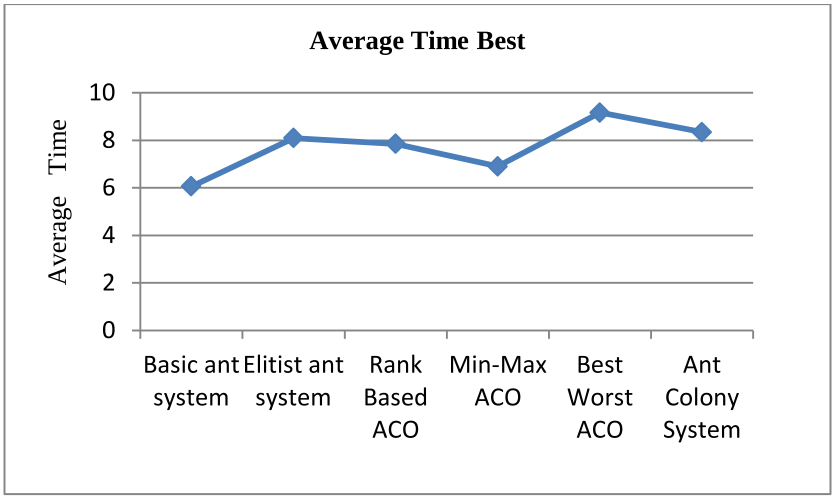


GRAPH II

3.

TABLE III

S. No.	Variants of ACO	Average Time Best
1	Basic ant system	6.06
2	Elitist ant system	8.09
3	Rank Based ACO	7.85
4	Min-Max ACO	6.9
5	Best Worst ACO	9.16
6	Ant Colony System	8.34



GRAPH III

CONCLUSION

The system tries to implement the solid waste management routing problem using Multi-Objective Ant colony optimization. In the research, the problem of routing in solid waste management is the main point of focus in thesis. Our technique is based on the various variants of ACO i.e. basic ant system, elitist ant system, rank based system, min-max system and best-worst system. Some of the main factors studied in each of the case are average best tour, average number of iterations and average time best. The average best was found worst in case of elicit ant system and average time best was found to be best in case of rank based system. We found average number of iteration is minimum in case of Basic Ant System followed by the min-max system.

REFERENCES:

[1] Er. Lavina Maheshwari,Er. Pankaj Kumar,"Solid Waste Routing by Rank Based Ant Colony Optimization" *IJSRD - International Journal for Scientific Research & Development| Vol. 2, Issue 10, 2014 | ISSN (online): 2321-0613*

[2] Ansari Muqueet Husain*, Shaikh Mohammad Sohail**, V. S. Narwane***"Path planning of material handling robot using Ant Colony Optimization (ACO) technique" International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com Vol. 2, Issue 5, September- October 2012, pp.1698-1701

[3] NIKOLAOS V. KARADIMAS, MARIA KOLOKATHI, GERASIMOULA DEFTERAIOU, VASSILI LOUMOS, Ant Colony System v/s ArcGIS Network Analyst: The Case of Municipal Solid Waste Collection, 5th WSEAS Int. Conf. on ENVIRONMENT, ECOSYSTEMS and DEVELOPMENT, Tenerife, Spain, December 14-16, 2007

[4] Dorigo, M. and Gambardella, L.M., Ant ColonySystem: A Cooperative Learning Approach tothe Travelling Salesman Problem. IEEETransactions on Evolutionary Computation, Vol.1, 1997.

[5] Solid Waste Management Principles and Terminologies, (Prepared by Prakriti, Centre for Management Studies, Dibrugarh University as part of the National Environment Awareness Campaign, 2006 – 07 for distribution through its website http://cmsdu.org).

[6] http://www.cyen.org/innovaeditor/assets/Solid%20waste%20management.pdf

[7] Solid Waste Management in Asian Perspectives,Prof. C. Visvanathan.

[8] Ant Colony Optimization ,*Vittorio Maniezzo, Luca Maria Gambardella, Fabio deLuigi.*

[9] *Mr. Ankit Verma* and Prof. B.K Bhonde*** "Optimisation of Municipal Solid Waste Management of Indore City using GIS" *International Journal on Emerging Technologies* 5(1): 194-200(2014) ISSN No.(Online): 2249-3255

[10] Nuortioa T., Kytöjokib J., Niskaa H. and BräysyO., Improved Route Planning and Scheduling of Waste Collection and Transport, 2005,http://www.sciencedirect.com/science?...3520c6c9ea5&ie=/sdarticle.pdf (Accessed on February10, 2007).