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Optimization of CO2 Emission, Driving Cost and Time Using Pollution Routing Protocol and ST-70 Benchmark

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Abstract. According to Vedic hymn, "The air is the spirit of all deities. It exists in all as life-breath. It is capable to move everywhere. We can't see it. Only we can hear its sound. We are praying to air God." Vehicle is creating and will create CO2 emission and eventually increase air pollution. Pollution has negative impact on our environment. Therefore, our main objective is to reduce pollution by vehicle. We can't derail development, that's why we can't stop vehicle. Only we can reduce the minimum distance covered by vehicle in an efficient manner to deliver high performance. Therefore, in order to reduce distance covered by vehicle, we are using vehicle routing protocol (VRP) based on genetic algorithm. VRP with consideration of pollution also called pollution routing protocol (PRP). Therefore, this project optimizes CO2 emission, driving cost and driving time using PRP in order to preserve air and protect air God.

Keywords— Greenhouse Emission, Driving Cost, Driving Time, Genetic Algorithm, Vehicle Routing Protocol

1. Introduction

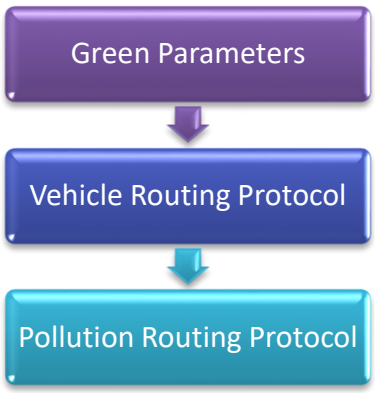

Figure 1: Relation between Pollution Routing Protocol and Vehicle Routing Protocol

This paper deals with Genetic Algorithm & Vehicle Routing Problem based Pollution Routing Problem (PRP) as shown in Figure 1 with consideration of greenhouse emissions (CO2), fuel, travel distance, travelling time and their costs.

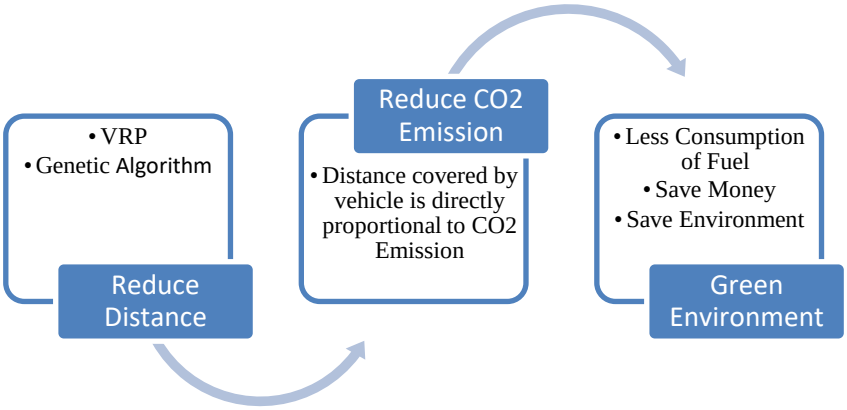

Figure 2: Transformation of VRP into PRP for Green Environment

For problem ST-70 (Result in Table 1-3), there are 70 customers which are going to be served and we assumed that population size of the genetic algorithm is 15 and number of generation is also 15. We have calculated the distance for that population size and its corresponding fuel consumption, driving time and driver cost are also determined.

2. Related Work

The Time-Dependent Pollution-Routing Problem (TDPRP) introduced in [1] and explained with different objectives. Application of genetic algorithm in vehicle routing problem (VRP) with time window constrained is given in [2]. In [3], parallel hybrid genetic algorithm is proposed for VRP with time windows is explained by a master–slave message-passing model. With coordinating genetic operations and deals with selection of parent whereas slave elements simultaneously perform reproduction and mutation operators. For quality optimization the parallel algorithm extends its sequential portion. Multi Depot VRP based on hybrid genetic algorithm is discussed in [4]. A goal programming and genetic algorithm based multi objective vehicle routing problem with time windows (VRPTW) is presented in [5]. The rapid growth of reverse logistics activities make it compulsory evaluate optimized path for simultaneous pick up and deliveries. A genetic algorithm is proposed to solve the problem in [6]. In [8], Vehicular Sensor Network (VSN) is thrust area to monitor city environments in terms of air pollution and Intelligent Transportation Systems. In [8], Choi Okyoung et al. analyze problem in routing data packets with minimum delay in VSN in terms of i) statistics of vehicle traffic ii) cast routing iii) intelligence of future trajectories of vehicles such as buses. Choi Okyoung et al. propose unique road network graph model that incorporates these three factors as routing metric. This paper considers length of the edge. Choi, Okyoung, et al. (8) formulate the packet routing problem as a Markov Decision Process (MDP) based on both network model and delay function, and also develop an optimal routing policy by solving the MDP. Reduction in delay is going to play an important role in reduction of pollution. Reference [9] presents mobility information of vehicles and digital map on city roads based inter-vehicle routing protocol in order to solve those problems in urban area. Mobility information includes the position, velocity, and direction of vehicles. We can calculate distance using available position, velocity, and directions of vehicles. Finally, we can calculate pollution by vehicle in order to cover the distance. In logistic transport industry, individual demands and the diversity requirements are matters in transport operation; [10] focused on the VRP. New genetic algorithm is used to achieve optimized solution in [10]. Initially, we use natural number coding in order to simplify the problem. Secondly, use individual amount control choice strategy to guard the diversity of group;

approach in [10] also improved route crossover operation to avoid goods damage. Finally, the good performance in terms of minimum distance and minimum pollution of modified algorithm can be proved by experiment calculation and examples [10]. Reference [11] deals with Min Max Vehicle Routing Problem. According to model discussed in this paper, hybrid genetic algorithm is applied for optimized solution [11].

3. **Results**

For problem ST-70 (Result in Table 1-3), there are 70 customers which are going to be served and we assumed that population size of the genetic algorithm is 15 and number of generation is also 15. We have calculated the distance for that population size and its corresponding fuel consumption, driving time and driver cost are also determined. In Table 1-3, the minimum distance is found to be 694.110Km and the corresponding fuel consumption, driving time and driving cost is 128.895 Liter, 40.686 hours and 1,220.58 (INR) respectively. Where remuneration for driver is Rs 30 per km.

A. Analysis of Fuel Consumption to control CO_2 Emission

TABLE I. Distance Versus Fuel Consumption in PRP For ST-70

Distance (Km)	Fuel Consumption (Litre)
709.66	131.890
713.998	132.639
704.099	130.800
697.713	129.614
704.099	130.800
702.582	130.518
754.147	140.098
716.836	133.166
745.960	138.577
718.586	133.491
712.090	132.285
694.110	128.895
695.255	129.157
715.319	132.885
702.582	130.518

B. Analysis of Driving Time to deliver High Performance

TABLE II. Distance versus Driving Time in PRP for ST-70

Distance	Driving Time (Hours)
709.66	41.082
713.998	41.183
704.099	40.935
697.713	40.776
704.099	40.935
702.582	40.897
754.147	42.817
716.836	41.254
745.960	41.982
718.586	41.297
712.090	41.135

694.110	40.686
695.255	40.714
715.319	41.216
702.582	40.897

C. Analysis of Driving Cost to Make Cost Effective System

TABLE III. Distance Versus Driving Cost in PRP For ST-70

Distance (km)	Driver Cost @ 30 (INR) per km
41.082	1232.46
41.183	1235.49
40.935	1228.05
40.776	1223.28
40.935	1228.05
40.897	1226.91
42.817	1284.51
41.254	1237.62
41.982	1259.46
41.297	1238.91
41.135	1234.05
40.686	1220.58
40.714	1221.42
41.216	1236.48
40.897	1226.91

4. **Conclusion**

In this project, we have implemented genetic algorithm for basic vehicle routing problem (assuming there is one vehicle that starts from a depot, serves all the customer and return back to same depot) and determined minimum distance travelled by that vehicle. Then, for that minimum distance, we have calculated fuel consumption, driving time, driver cost and CO2 emission in order to determine pollution using vehicle routing protocol for different benchmark. Pollution is also reducing with reduction in distance travelled by that vehicle. Eventually, we are contributing for green earth.

5. **Future Scope**

In future, we can extend this project from one vehicle to multiple vehicles and calculate fuel consumption, drive time, driver cost and CO2 emission for each and every vehicle using optimization principles of pollution routing protocol. There is also an open scope to design pollution aware vehicle in future. Now research communities are moving toward conception of self-driving vehicle. Our approach is an automated distance calculation using genetic algorithm that is eliminating the choice for manual driver that especially need for minimum distance determination using past experience and heuristics.

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