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A Genetic Approach for Optimized Routing of Fleet of Electric Vehicles

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***Abstract*— *One of the way to deal with enhance transport proficiency and manageability is electrification of vehicles or transport. By and by the cost of vehicles are connected with the securing taken a toll and battery support. With a specific end goal to deal with the accessible available energy efficiently can lessen the size of batteries that is as opposed to utilizing a solitary extensive battery can isolate it into little modules. At present taxi administrations and urban conveyance organizations are advancing the use of electric vehicles into their fleet. Available route planners don't considering the attributes and charging stop prerequisites for the EV armadas in basic leadership. Along these lines it will brings about a non-ideal routing arrangement. This work attempt to present an optimal routing calculation for finding the courses for fleet of electric vehicles which won't as it were consider the battery furthest reaches of the vehicle, additionally the simultaneous utilization of charging stations along the route. It will limits the related cost of travelling time, charging time and the energy utilization along the route and this depends on a transformative hereditary calculation with learning methodology. It likewise considers the limit or the aggregate accessible energy in the charging station and the kind of batteries utilized inside the vehicle. So also it considers the circumstance of any sorts of failures at the charging station and there is choices for isolated reviving of hubs when the limit terminates. This calculation finds an achievable arrangement in a sensible measure of time and disperses the vehicles among the charging station to limit the blockage.*

***Keywords*— *Battery capacity, Battery recharge, Driving range, Electric vehicles, Recharging or Replenishment station, Route planners.*

I. INTRODUCTION

Thesedays, principle issues with respect to the contamination are the outflow of greenhouse gasses and carbon dioxide into nature. Primary option to reduce this is to utilize battery electric vehicles. Subsequently European Union and different nations are broadly advancing electric vehicles into their fleet to wind up plainly the piece of green vehicles or green coordinations. As of late it turn into the one of the primary research zone in the vehicle segment. The primary thing that lessens the popularity of electric vehicles are its short driving extent and its expansive charging time. Indeed, even with the accessible quick recharging advances a battery energize will take a few minutes and along these lines it will bring about the congestion at the charging stations.

Electric vehicles (EVs) can be fuelled by either regular or regenerative energy sources and they can recuperate some of their active as well as potential energy at deceleration stages. The recovery or regenerative energy expands the cruising scope of EVs by around 20 percent in regular urban settings. Be that as it may, the acknowledgment of EVs is still hindered by constrained battery limit, which as of now permits cruising scopes of just 150 to 200 kilometres. Consequently, exact forecast of outstanding cruising extend, vitality mindful directing and upgraded charging stops are vital issues for EVs soon.

In congested zones the simultaneous and concurrent demands for charging would result high waiting time at the charging station, in this manner influencing both charging system and vehicle travel time.

The present work addresses the issue of finding the optimal charging station succession mutually for all vehicles of the fleet considering a hidden enhancement issue. The fundamental commitments of this work are the formal explanation of the enhancement issue that is agreeable to an immediate arrangement, the adjustment of evolutionary genetic algorithm for the arrangement of the problem, the particular shape of portrayal of the arrangement as paired network which incorporates the associated travel sales man problem, the underlying population definition that permits to rapidly recuperate from non-attainable arrangements, the hybrid that incorporates an enhancement sub-problem alongside its guess what's more, the meaning of the learning system.

II. LITERATURE REVIEW

Some approach addresses the issue of energy optimal routing for electric vehicles as an augmentation of general briefest way issue. In any case, most usually used shortest path figuring like disagreement progressive systems, expressway orders and travel vertex chains of importance can't be associated with our issue in perspective of the closeness of negative weights that result from recuperation. Also, SP does not consider the objectives that result from the discharge and restore traits of the EV's battery pack, specifically that it not either can be discharged underneath zero, or charged over its most noteworthy farthest point. These two conditions on the charge level of the battery can be viewed as hard and sensitive objectives, independently, on possible interstates: a course is infeasible if there is a point where the required essentialness outperforms the charge level, and a course is less supported if there is a point where imperativeness could be recouped however the battery's most outrageous breaking point is outperformed [1].

A path in which EV does not run out energy is called feasible .there is no feasible path from source to destination without reloading. We should make decision where to recharge reasonably. So we have to balance distance or time, energy consumption and reloading efforts. This may lead to more complex optimization criteria and it will reflect in the following questions.

3. Find the shortest/quickest feasible path with maximum k recharging events.

4. Find a feasible path with minimum number of recharging events and bounded distance/travelling time [2].

Some other approaches are based on time based optimization criteria's apart from the energy based optimizations. That is the time required to recharge vehicle at the charging station. Some approaches assumes that vehicles travel at a constant speed hence we can predict the arrival time of vehicle at the charging station in a deterministic way [3]. Another approach assumes that recharging station is always available when request is made but it is not possible in real cases [4].

One approach introduces an electric vehicle routing problem with time windows which associates the case of recharging at one of the available stations using a recharging scheme that is the recharging time depending on the charge available on the vehicle at the arrival time of the station [5]. Moreover, the A large portion paramount useful. Necessities from claiming logistics suppliers utilizing battery EVs, in particular limit imperatives on vehicles Furthermore. Client time windows are incorporated. It also aims to minimize the number of employed vehicles and the total travelled distance. The effects for recharging time Also vehicle extent need aid determined on focus trends done. Particular fleet aspects including fleet size, Normal tour distance, also aggregate fleet distance travelled [6].

Another study presents a time-dependent model with time window constraints that incorporates speed and provides a schedule in transportation. Transportation system efficiency enhancement is its main objective. This model introduces different speed limits for different times of the day and it proposes a simulated annealing algorithm to find solutions in a timely manner with high quality. Here the speed control and travelling time were studied using a mixed integer programming model [7].

In distance based optimization criteria some approaches assumes that vehicles can complete the entire trip in a single charge with no charging stops in the midway. Modern vehicle's navigation system are equippied with a optimum path selection modules that are used for finding the shortest path between the origin and destination pair in a road network. Methods used for finding the shortest path in EVs are different from those are used in internal combustion engine vehicles.

One approach assumes that a vehicle's optimum path selection module is placed in the navigation system. Electric vehicle's navigation system are connected with the Global Positioning System (GPS) OR V2X communication system to obtain the information regarding the road networks. Optimum path selection unit uses the information of navigation system to find shortest paths [8].

Promising alternative to reduce the emission of greenhouse gases are the usage of battery electric vehicles. In earlier years battery electric vehicles failed due to the higher battery prices and shorter driving range. It is necessary to visit charging station with limited battery capacity during tours. There are mechanisms to monitor the current state charge in the vehicle and the availability of the charge in the battery at the arrival time of vehicle in the charging station [5].

Delay or waiting time due to looking for a charging station is one of the important parameter to be considered. Due to the high expense of building new charging stations it is important to consider the location of charging stations.

Here one approach defines a query and reservation protocol between an electric vehicle and routing service which enables the user 1) to query about the availability of the charging station in advance at any time 2) if any charging station is available, reserve a time slot to recharge 3) to be notified when a charging station is available. The routing service is one which serve a region and provide a broker between the EV user and the energy provider. Broker provides the best charging station match with respect to the availability of required resources needed for charging. User provided information consists of two parameters that help the user to route and reserve resources at the selected charging stations. Time window that I the estimated arrival and leaving time and the energy needed [9].

III. PROBLEM DEFINITION

EV routing problem addressed in this work is defined as the selection of the charging stations (CS) per each origin destination (OD) pair. This is done in such a way that it is feasible with respect to the energy available at the charging station, the concurrent use of the charging stations and the vehicles battery limit.

IV. METHODOLOGY

The proposed solution consists of mainly four phases. They are:
1. Node Creation
2. EV Charging Solution
3. Calculating Path Cost
4. Map Construction

1. Node Creation

In node creation a graph is made out of nodes and directed edges. Here node is considered as a charging station. The directed edges define the connection from one node to another node. A node also called as a vertex is a discrete position in a graph. Edges can be directed an undirected. Edges have an associated distance also called cost or weight of the graph. The distance between two nodes a and b is labelled as [a,b]. Mathematically, a graph can be denoted as G= {V,E}, meaning that a graph is defined by a collection of vertexes (V) and a set of edges (E). The order of a graph denotes the number of nodes. Similarly the size of a graph denotes the number of edges.

2. EV Charging Solution

To resolve the concurrent charging demands, genetic algorithm are applying including a local search in order to speed up the convergence and recover from non-feasibility of

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initial population [10]. In the following sub-sections specifying the different aspects that characterize the algorithm:
1. Population formation
2. Pool generation
3. Crossover function
4. Mutation
5. Fitness computation

In genetic algorithms, crossover is used to generate an offspring out of two or more parents. This allows exploring new solution space based on previous experience. Normally, the possible cross over are the following (Fig. 1)

- Horizontal Crossover: routes are taken fully from parents, but each route can come from different parents.
- Route r -slicing: each route is split selecting r – 1 points, each segment 0 - j1,..., jl-1 - jl , ..., jr-1 - L – 1 is taken from one of the parents.

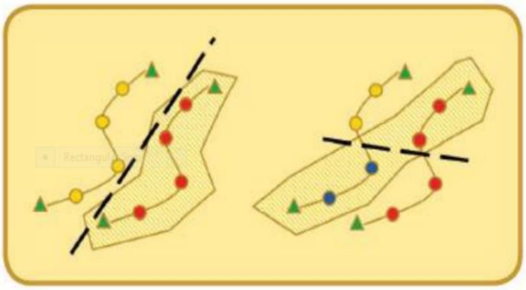

Fig. 1. Crossover Possibilities: Left is Horizontal Crossover; Right is an Example of One Point Crossover [10].

These crossovers may result in a worst solution than the one generated by each parent. For this reason an alternative approach is used. A two point selection for each route may potentially generate non-feasible solutions. To avoid this, the following method is adopted. From the two parents the nodes are selected in such a way that which will minimize the probability of selecting the same charging station. This implies that the solution of the parents is not changed at level of the single rout e. This by itself is another combinatorial problem, but in this case the possible routes are from two sets, so there are 2 routes per trip. The solution of the proposed sub-problem is defined as follow in (Fig. 2).

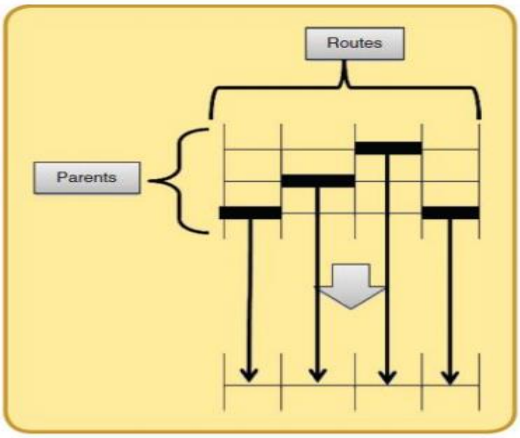

Fig. 2. Optimal Crossover [10].

Here start from one parent solution and look if there are routes from the other parents that lower the number of concurrency at charging stations. This combinatorial problem can be defined as allocation of the two (or more) parent routes in an optimal way. Once an offspring is generated, it can be randomly mutated. Mutation helps in exploring new area of solution space. Used Pr = 0.2 of mutation for each charging station and route, which is a good compromise between randomness in the mutation and memory of parents' genome Mutation can be visualized at the level of the single route. The mutation can remove a charging station, add an additional charging station to the current set or can substitute one node, with another one.

Similarly administrator also can manage the electric vehicle routing system apart from the user. He can add capacity or energy to each of the nodes or charging stations by entering into the system using his login id or password. In case of any types of disappointments or failure at the charging station then the administrator can select that charging station and put it into a maintenance phase, at the time of maintenance that node or charging station will not be displayed in the route. After completing the maintenance administrator can add that charging station to resolve phase. In case the capacity of any charging station has expired, an error message will be generated and at that time administrator can select that node separately and can be recharged.

3. Calculating Path Cost

The cost c(P) is defined as the amount of energy consumed or gained by an electric vehicle when passing along an edge in the network. The amount of energy consumed or gained and the path cost are discussed in the following subsections

Potential Energy EP

This energy results from the elevation of a vertex. Elevation of a vertex is denoted as z. When traveling along an edge (a,b) the energy Cp(a,b) = Ep(z(b))-Ep(z(a)) has to be spent when z(a)< =z(b) or recuperated when z(a)> z(b) . The cost Cp (a,b) of an edge (a,b) is given by:

$$Cp(a,b)=mg((z(b)-z(a)),$$

Where m is the mass of the vehicle and g is the gravitational acceleration.

Other Energy Losses EL

Other energy losses are due to the rolling, aerodynamic resistances or conventional losses, when passing an edge e= (a,b). This loss increases linearly in l and monotonically in s.

Path Cost

The functions Cp (a,b) and CL (a,b) sum up to an edge weight and is given by

$$C0 (a,b) = Cp (a,b) + CL(a,b).$$

The weighted graph G = (V,E,c) can be denoted as the energy graph.

After calculating the path cost, costs of different routes are compared and from which the route which is having minimum cost is selected as the offspring or the outcome of the algorithm.

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4. Map Construction

Simulation and analysis are present in this section. To route the EV through appropriate charging stations, modelling energy-optimal routing as a shortest path problem with constraints for battery-powered electric cars with recuperation. The computation of energy optimal path considers the regenerative energy and the EV parameters. To compute an energy optimal route, the road network is considered to be a directed graph G = (V,E). Vertices V represent points on the map and edges E represent connections between these points corresponding to the road sections. Each vertex is assumed to have an elevation z. The length of each edge segment is denoted by l and the speed limit on the edge is considered as s. The path P, which is the desired output, is then a sequence of k vertices. The cost is defined as the amount of energy consumed or gained by an EV when passing along an edge in the network.

Simulation is a test network by randomly placing charging station in a square grid. This network is kept constant throughout the simulation but we can randomly select the origin and destination pair. Time graph of the algorithm is shown in Fig. 3. It shows that the accuracy of the algorithm increasing in timely manner with respect to the increase of the number of iterations. That means as the number of iterations increases there is the probability of getting fittest or more accurate solution or output.

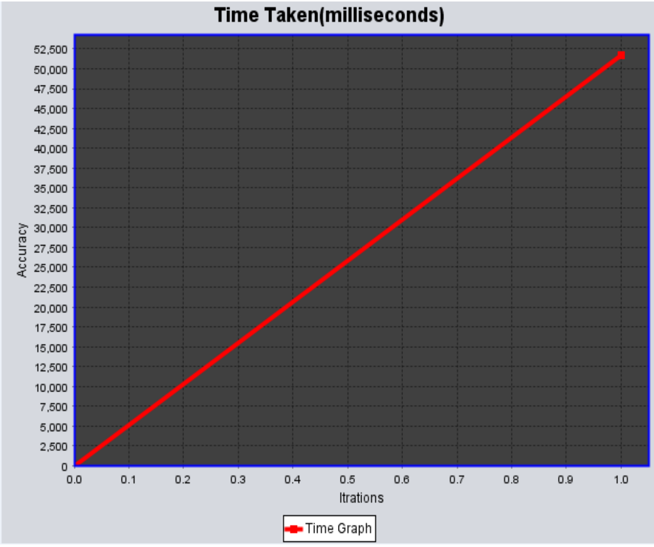

Fig. 3. Time graph.

V. Conclusion

This paper addresses the issue of simultaneous charging for EV fleets by processing routes that limiting the related cost constituted by travelling time, charging time and the energy utilization along the route. The planned issue is settled by adjusting evolutionary genetic algorithm. The assessment demonstrated that, with the proposed techniques for EV situation, an optimal arrangement can be found in a sensible measure of time and EVs can be allotted to the accusing stations of a lower clashing circumstance. It additionally considers the circumstance of any sorts of failures at the charging station and can at first add ability to the charging station. There is possibilities for particular reviving of hubs when the limit terminates.

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