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Green route: An Ecofriendly Route Suggestion and Description Based on Congestion and Air quality

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Abstract*: Travelling is a part of our daily life. We all travel from one place to another. The ultimate aim of people is to reach the destination as soon as possible. In wide-scale urbanization processes the route planning is the problem, whilst addressed thoroughly for a single traveler in terms of shortest path computation, becomes quickly unwieldy when dealing with a set of travelers. Smart cities and developed countries are now taking efforts to tackle urban pollution and current travel planners concentrate mainly on travel time and distance to be covered. Here, in addition to distance, air quality and road congestion that affect travel time, crowd sourcing is also considered for finding the best and healthier route. Ant colony optimization is used to select among different routes also used to find optimal route considering the air quality, congestion, distance are used as the parameters for pheromone updation. Here we provide a congestion-less and eco-friendlier route with the help of Google map API and ant colony optimization by exploiting feedback-driven on participation and route suggestions from personal interest. In this sense, collective intelligence and swarm based paradigms are adapted to an innovative crowd sourcing pattern towards the data storage is cloud. In particular the stigmergic algorithm for probabilistic route planning, including the distributed crowd sourcing paradigm based on number of participants, has been used to find the optimal path finding using ACO (ant colony optimization).

***Index Terms*: Traffic Congestion, GSM, DTSP, ACO (ant colony optimization)**

I. INTRODUCTION

Travelling became an inevitable part of everyone's life. It is the movement of people from one geographical location to another. People want to travel and explore new routes, this includes travelling by cars, public vehicles, bicycles or by walking. In today's world as development occurs at a faster rate, vehicles on the road are increasing day by day. But the major problem faced is that the development in road infrastructure is happening at a very low destinations. However the map system doesn't provide any description about a path. When an individual travels to a new city for business or vacation or is simply relocating to a fresh setting, the person needs a method to receive information on the sites to see and routes to utilize. We are living in an era, where the people are ready to save time at any cost. For most of us, time is the most valuable source that we all want to save. In most of the major cities, the traffic congestion is a major crisis. The best way to reduce the traffic and manage the traffic is to reroute the vehicles. The vehicles must be rerouted to a less congested route. Travelling through a polluted route is one of the major causes for most of the health issues in human beings. Rerouting the vehicle through a less polluted route will help people lead a healthy life. Finding out the pollution free route is important in such situations. The aim of this work is to propose a system that does vehicle rerouting. System ensures the user to travel through least congested and polluted route.. It makes use of Google map API to determine the route information between a source and a destination. The users will be suggested a route with less congestion and pollution among an available set of routes. Ant Colony Optimization is used to select the optimal route among the available set of routes.

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II. RELATED WORKS

Many previous works were done for detecting the traffic congestion. There were many works that concentrated on the identification of congestion at a particular point by a dedicated device [1]. In such works, a dedicated device was installed which could determine the velocity of the vehicle or the number of vehicles. Devices such as inductive loops were used as such devices. But the installation and maintenance of such devices were difficult. Other method included a camera device installed in an airplane which is at a high altitude [2]. The images taken at regular intervals and the processing of such images were done to determine the congestion rate. Involving such tasks also makes the system more tedious and expensive. Video data was also used to collect such information. In [3] RFID and GSM technologies were used. In this technique, the vehicle congestion is detected using signals send from an active beacon. This paper also discussed about the various techniques to prevent the congestion. In [4] the technique used was change in earth's magnetic field. The movement of vehicles was taken as a measure to determine the congestion conditions. In [5] a real time routing of vehicles during traffic congestion was considered. The shortest path between a pair of nodes was considered. But to be exact, stochastic shortest paths were to be considered. But the integration of stochastic shortest path problem with the dynamic vehicle routing problem was difficult.

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A. Traffic congestion

An inductive loop [6] is a communication that uses the technology of electromagnetism and for detecting the system which uses a moving magnet to induce an electric current in a nearby wire. For transmission inductive loops are used and for detection of metal objects in a metal detectors or vehicle presence indicators. Inductive loops that can be placed in a road bed to detect vehicles that pass over the loop, while more sophisticated sensors estimate the speed, length, and weight of vehicles and the distance between them. While this system works for traffic at all speeds, it does have the drawback of a high error rate in detection and transmission of traffic information. Other drawbacks include cumbersome installation of inductive loop devices, tedious maintenance and the improbability of managing traffic locally.

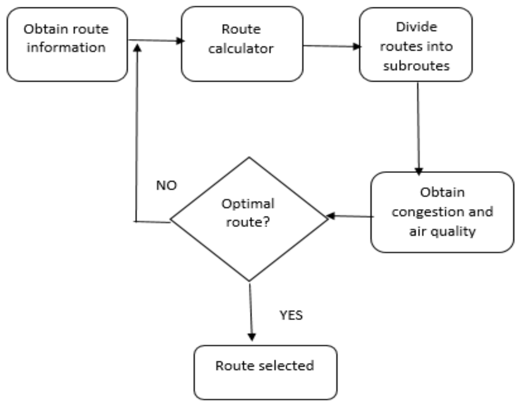

Fig. 1. Architecture of the system

B. Why ACO?

The travelling salesman problem is considered as one of the simplest problems. It is an NP-hard problem, meaning that there is no polynomial-time algorithm for solving it. The travelling salesman problem can be defined as: given a collection of cities and links between them. The objective is to find shortest Hamiltonian cycle that would visit all the city exactly once and returns to the city where the journey started. Many heuristics, metaheuristic methods and exact methods were proposed to solve this problem. But as the problem size increased, the computation time also increased. So heuristic and metaheuirstic methods were appropriate in such cases.

In [7] a dynamic travelling salesman problem can be viewed as sequence of many static TSPs that change over time. For a DTSP, the weights between edges may be subject to changes. If the time interval between the changes is long, then better way to solve it is using exact methods, heuristics or metahueristics. Such methods are capable of finding out solutions in case of symmetric TSPs in seconds. But in most real-time cases, the interval between changes is short and also dynamic changes are mostly asymmetric. Among the metahueristics developed, the most extensively used method is ant colony optimization. It is extensively used to address the DTSPs [8] due to their adaptation capabilities. Pheromone trial generated before a dynamic change could be used after the change to speed up the re-optimization process. Many changes were adopted into ACO [9] and one among the new technique was to use a local search operator. The pheromone update is done using one of the best performing ACO algorithms, the local search operator used is the string and unstring operator.

III. PROPOSED WORK

A. Ecofriendly Route based Architecture

The proposed method is a traffic congestion and pollution detection system that aims at providing a best and optimal route at lower cost. The users will be directed towards least congested and polluted route. The main modules for this system includes obtaining the route information from Google map API, obtaining intermediate points in the route, finding the congestion with the help of data collected from traffic API, finding the air quality at specific areas, finding optimal route using ant colony optimization considering distance, congestion and air quality as parameters.

C. Route Identification

Google map API can help to find out route between a source and a destination. It can provide multiple routes. But processing of this entire route will be a very hard task. So the intermediate points in that route can be determined using API and can be used to segment the routes and provides map related information at real-time. Map APIs avoid the requirement of saving large map data or learning new map tools. It can generate routes between up-to 23 locations for driving, walking or cycling. Up-to 3 alternative routes are provided and users can drag routes on the Google Map APIs provides real time solutions of problems like shortest route finding. There may be many routes between a source and a destination. The Google map provides services like Directions Service to provide the route information and Places Service to provide information about a particular area. It also helps to identify the junction points in the route using services like waypoints are shown in fig: 2

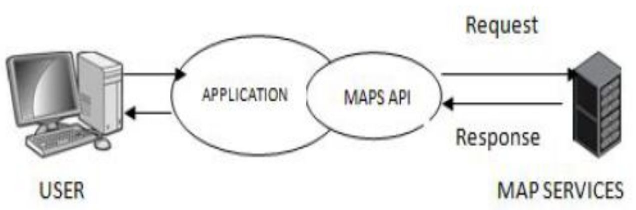

Fig.2 .Interaction using google API

B. Congestion Estimation

Traffic congestion can estimated with the help of GPS data [10]. The GPS data obtained from probe taxis will contain the location, speed etc. information. The available congestion detection systems are mostly location based, which have dedicated device installation and continuous monitoring of its recordings. This method of congestion detection [11] can help in collecting congestion related information at a very low cost and effort. This taxi movement data is tracked continuously and recorded for efficient management of taxi companies. Traffic congestion is caused due to the increase in the number of vehicles.

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As the number of vehicles at a particular region is high, the individual speed of the vehicles decreases. As a result of which the time taken to travel increases. This leads to loss in time, effort, fuel etc. Proposed work measures congestion as a decrease in speed of the probe taxis in that area. The system reads the vehicle data and matches it with the segment and identifies the vehicle travelling in that route [12]. The velocity of the vehicle can be identified by tracking the latitude-longitude pairs shared by vehicle at adjacent time intervals. This is done with the help of traffic API.

C. Air quality Estimation

Air pollution is the introduction of particulates, biological molecules, or other harmful materials into Earth's atmosphere, causing disease, death to humans, damage to other living organisms such as food crops, or the natural or built environment. The proposed method integrates Breezometer API. It is an API used for providing the air quality detail of a particular area. Given the latitude longitude pair of an area, the API returns information such as fair air quality, good air quality etc. Breezometer covers those areas by extrapolating detailed air pollution maps from monitoring station data with algorithms that incorporate meteorological, topographical, and real-time traffic information [13]. Breezometer has created a new unified index for determining air quality. The value ranges from 100 (Excellent air quality) to 0 (Poor air quality) and are determined based on concentrations of predefined air pollutants depending on local standards. History API calls can be made to return both the air Quality data for a specific date/time in a specific location. Air Quality data for a range of dates in a specific location.

D. Ant Colony for Optimization

The ant colony optimization helps to search through a set of solutions and reach on an optimal solution. In this work, the ACO will help to determine an optimal route from an available set of routes. The length of the road segment will be the parameter deciding the edge to be selected. Along with distance any desired parameters can be incorporated with the help of pheromone update. The average velocity of vehicles in a route and the air quality indices of a route are the parameters considered which control the amount of pheromone to be updated. The selection of edge is also based on the amount of pheromone content in that edge.

The movement of ants provide parallel and independent search for the route in the solution space, with the help of dynamical change of pheromone trail. Ant is an elementary unit which has the ability to learn. It is able to find acceptable solution to the given problem, due to collective cooperative work of ants with other members of population. In each iteration ant's travel from the source to destination, travelling through different sub-routes. Density-based ant colony model [14] is used in this system. Initial pheromone is set to 0.001. Total number of ants is set to 10 and total number of iterations is set to 100. The pheromone constant parameter is used in depositing pheromones on the map. The pheromone content is decided based on the velocity possible in that sub-route. The pheromone content is proportional to the velocity possible. After ant moves from one point to another it deposit a pheromone which strengthens the path for other ant following the path ,the pheromone trail which determines the next node to be followed: node i, an explorer ant m chooses probabilistically node j to observe next using the following probabilistic rule:

$$P_{ij}^{k}(t) = \left\{ \frac{[\tau_{ij}(t)]^{\alpha}[\eta_{ij}]^{\beta}}{\sum_{l \epsilon N_i^k}[\tau_{ij}(t)]^{\alpha}[\eta_{ij}]^{\beta}} \qquad if\ j \epsilon N_i^k \right\} \quad (1)$$

Where each term specifies:

- $\tau_{(i,j)}$: The strength of pheromone deposited by each ant on the path (*i*,*j*). The strength changes during the run of the program.
- α : The intensity control parameter.
- $\eta_{(i,j)}$: The gain of the path (*i*,*j*) which is determined by $\eta_{(i,j)}=1/l_{(ij)}$, where $l_{(ij)}$ is the least distance of move from node point *i* to the destination node point *j*.
- β : The visibility control parameter.

E. Algorithm for ecofriendly route

Optimal Path(s,d)
 min_d=0
 medium_d=1
1. For the source(s) and destination (d)
2. Get the nodes between s and d from map
3. Get the intermediate nodes from map
4. For each node available to ACO algorithm
 i) Compute distance of each:
  if distance < min_d
  Distance = min_d
 ii) Compute air quality for each:
  If air quality < medium_d
  medium_d =low quality
 iii) Compute congestion
 iv)Feedback from personnel interest
5. Recommend the best optimal path from the parameters.

F. Route Optimization

Ant colony optimization (ACO), a probabilistic technique is used for finding optimal route. This is a general technique used for solving computational problems which can be reduced to finding good paths through graphs. ACO is inspired by the ants' foraging behaviour. At the core of this behaviour is the indirect communication between the ants by means of chemical pheromone trails, which enables them to find short paths between their nest and food sources [15]. This characteristic of real ant colonies is exploited in ACO algorithms. One best path must be selected from the available set of paths which will be less polluted and congested. To obtain the optimal path from available set of paths, ant colony optimization is considered. Ant colony optimization requires a graph network where each of the nodes represents the intermediate points of a route and the edges represents the sub-routes.

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Optimization can consider the distance as the cost matrix for the links between the cities. The main advantage is that any parameter can be included other than distance with the help of pheromone updates. The ants select the route based on pheromone content in a link. So the average velocity and the air quality can also influence the selection of route. In this, a network is identified and using distance, congestion [16] and air quality, and applying ACO best route is selected. The length of the road segment will be the parameter deciding the edge to be selected. Along with distance any desired parameters can be incorporated with the help of pheromone update. The average velocity of vehicles in a route and the air quality indices of a route are the parameters considered which control the amount of pheromone to be updated. The selection of edge is also based on the amount of pheromone content in that edge. The major steps in applying ant colony optimization include:

- *Initializing ants*: A number of artificial ants are located at each source node and a specific value is assigned to each link of the problem graph. The link weight is the distance of each link in a shortest path finding problem.

- *The node transition rule*: It is defined and used for next node selection. Probability of choosing j as the next node from i by ant k is:

$$\text{Probability [next location]} = \text{pher}^{alpha}/\text{dist}^{beta} \quad (2)$$

Parameters alpha and beta indicates the relative importance that can be used to stress the importance of pheromone intensity and route cost. In this work the probability of selecting an edge between city x and y by the k^{th} ant is given by:

$$P^k_{xy} = \frac{(\tau^{\alpha}_{xy})(\eta^{\beta}_{xy})(\varphi^{\gamma}_{xy})}{\sum_{z\epsilon allowed\ y}(\tau^{\alpha}_{xz})(\eta^{\beta}_{xz})(\varphi^{\gamma}_{xz})}$$

(3)

- Here, the τ parameter is considered as the distance parameter of the route. η parameter is used as the parameter for indicating congestion rate of a particular route and ϕ the air quality value of that route. α, β and γ refers to the preference of the respective parameters.
- *Pheromone update*: With the help of node transition rules, ants move from one node to another. They also keep track of the visited nodes in their memory. Once the destination is reached, an ant backtracks to the original position using its memory and update pheromone in its link. On the other hand, the pheromone value of the links traversed by ants should be increased to increase the probability of their selection by other ants and is called pheromone reinforcement in the ACO[17] algorithm. Pheromone content will be updated as (1 - Pheromone evaporation coefficient) * Pheromone content)

- *Stopping procedure*: The ACO algorithm is completed by reaching a predefined number of iterations whereas; an ant is dropped by arriving at a pre-defined maximum number of hops before reaching its destination. Initial pheromone is set to 0.001. Total number of ants is set to 10 and total number of iterations is set to 100. Pheromone evaporation coefficient = 0.05. Alpha, beta and gamma values can range from 0.1to 1.0.The best path would be the one with less congestion and air pollution value. ACO [17] is used to select an optimal path along the multiple set of paths.

IV. RESULT

Travelling through a highly congested and polluted route is not only a tiresome work but also causes many of the health issues to human beings. So proper rerouting of vehicles is a necessary task in the current congested and polluted environment. Google provides a path which is optimal in terms of distance and travel time. But it may not be an eco-friendlier path. This system provides an eco-friendlier path considering three parameters-air quality, congestion and distance.

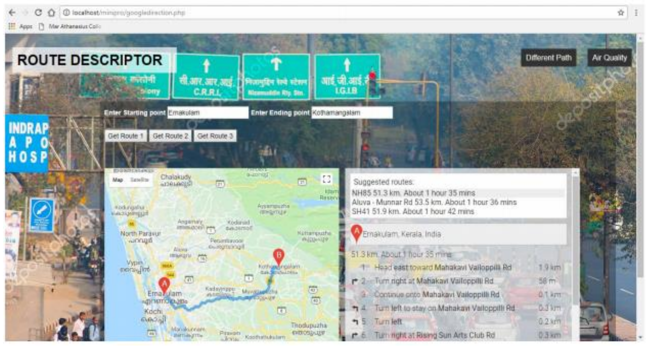

Fig. 2. Home page

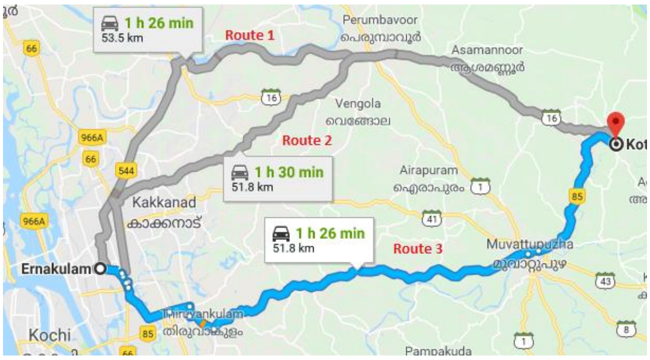

Fig. 4. Multiple routes are selected

Fig. 5. Considering air quality

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```
Head east toward Mahakavi Vailoppilli Rd 0.3 km -- ( 9.976216899999999 , 76.314864 ) -- Traffic Air Quality (1)
Turn left onto Mahakavi Vailoppilli Rd 0.8 km -- ( 9.9784676 , 76.31413739999999 ) -- Traffic Air Quality (2)
Sharp left to stay on Mahakavi Vailoppilli Rd \ 0.2 km -- ( 9.9722562 , 76.3167928 ) -- Traffic Air Quality (3)
Turn left 0.3 km -- ( 9.9729452 , 76.3181672 ) -- Traffic Air Quality (4)
Turn right at Rising Sun Arts Club Rd \ 0.1 km -- ( 9.9699654 , 76.31815829999999 ) -- Traffic Air Quality (5)
Turn left after KTM Service (on the left) 4.3 km -- ( 9.969004600000002 , 76.31821649 ) -- Traffic Air Quality (6)
Turn left after ICICI Bank ATM (on the left) \ 1.5 km -- ( 9.954348599999999 , 76.3448372 ) -- Traffic Air Quality (7)
At SN Jct , continue onto NH85 \ 0.7 km -- ( 9.9576282 , 76.3584365 ) -- Traffic Air Quality (8)
Turn right at Irumpanam Jct to stay on NH85 \ 2.1 km -- ( 9.9511641 , 76.3584699 ) -- Traffic Air Quality (9)
Turn left after Karingachira Jct (on the left) \ 26.4 km -- ( 9.943401399999999 , 76.3738249 ) -- Traffic Air Quality (10)
Turn left after Thiruvankulam Jct (on the right) 0.9 km -- ( 9.9904642 , 76.57803349999999 ) -- Traffic Air Quality (11)
Turn left at Muvattupuzha Football Club onto Municipal Stadium Road \ 12.3 km -- ( 9.992396599999999 , 76.5847746 ) -- Traffic Air Quality (12)
```

Fig. 6. Intermediate points in route

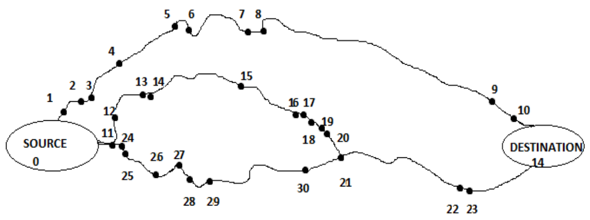

Fig. 7. Virtual graph network for applying ACO

```
Eco-friendly route finder using ACO
enter alpha(preference for distance) in the range 0.1 to 1.0 :: 0.2
enter beta(preference for congestion) in the range 0.1 to 1.0 :: 0.3
enter gamma(preference for air quality) in the range 0.1 to 1.0 :: 0.4
cost: 27067.05533656579, path: [0, 11, 12, 3, 4, 5, 6, 15, 27, 28, 29, 18, 19,
30, 20, 21, 22, 23, 10, 14]
```

Fig.8. ACO intermediate points

```
>>>
============ RESTART: C:\Users\lenovo\Desktop\NEENA ACO\paths.py ========
Enter your Source: 0
Enter your Destination: 14
Enter your Alpha: 0.4
Enter your Beta: 0.3
Enter your gamma: 0.3
Following are  paths considering the alpha,beta and gamma from 0 to 14 :
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 14]
```

Fig. 9. ACO optimal path finder

V. PERFORMANCE ANALYSIS

The developments in computing and communication have changed the living styles of common man. Now there is a trend to use route recommendation systems like Google to plan trips. By incorporation the congestion level and pollution level of an area in the decision of selection of routes, the routing applications can improve their performance. The experiments were conducted on different combinations of sources and destinations. These were in and around Ernakulam. It is a highly congested and polluted area in Kerala. So this area is well suitable for evaluation. There were 80 samples selected and the results were tabulated. The preference for distance, congestion and air quality are considered. Their readings were taken and the percentage by which the suggested route differs from the Google's suggested route is obtained. The table shows the sample of the results obtained. The Google's suggested shortest path from Kothamangalam to Ernakulam was route 2 which different preference levels of distance, congestion and air quality. Percentage change by which the route varied from Google's suggested shortest path were noted. Some of the observations are shown in the tables below.

Table 1. Distance preference parameter

α (Distance)	β (Congestion)	ϒ (Air quality)	%(Change from Google's suggested route)
0.1	0.2	0.2	67
0.3	0.2	0.2	46
0.5	0.2	0.2	37
0.8	0.2	0.2	20

Table 2. Congestion preference parameter

α (Distance)	β (Congestion)	ϒ (Air quality)	%(Change from Google's suggested route)
0.3	0.1	0.3	17
0.3	0.3	0.3	29
0.3	0.5	0.3	40
0.3	0.7	0.3	56

Table 3. Air quality preference parameter

α (Distance)	β (Congestion)	ϒ (Air quality)	%(Change from Google's suggested route)
0.3	0.1	0.1	18
0.3	0.3	0.4	36
0.3	0.5	0.6	52
0.3	0.7	0.8	68

VI. CONCLUSION

Travelling through a highly congested and polluted route is not only a tiresome work but also causes many of the health issues to human beings. So proper rerouting of vehicles is a necessary task in the current congested and polluted environment. Google provides a path which is optimal in terms of distance and travel time. But it may not be an eco-friendlier path. This system provides an eco-friendlier path considering three parameters-air quality, congestion and distance. From the observations it could be concluded that as the preference of distance was higher, the optimal route differed only slightly from the Google's suggested paths. But while the parameters congestion preference and air-quality preference were considered, this percentage of change was higher. The Google's suggested route varied highly when the air-quality preference value was considered. Another observation which could be concluded is that as the number iterations performed for ant colony optimization algorithm increased, the percentage of accuracy of eco-friendly route selection also increased. It can also be concluded that eco-friendliness value showed higher percentage when most of the sub routes were having good air quality values.

But as most of the places in India are polluted, 100 percentage of eco-friendliness was hard to achieve.

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