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Ant-Colony Optimization Algorithm for Travel Industry

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***Abstract*— Tours and Travel industry needs an intelligent scheduling system for the optimal use their assets, minimal fuel consumption, minimal waiting time for passengers. Popularly Travelling salesman problem has been solved by optimization programs like simplex method etc. In recent times, Artificial intelligence algorithms have been used effectively for designing a travel plan under given constraints. In current research Anti colony optimization is used for developing an intelligent digital platform for tours & travel agencies. The constraint is each city needs to be visited once. The objective is to arrive at minimal distance travelled leading to minima cost and time. Anti-colony optimization is applied to solve problems like pilgrimage, visiting important cities in a given country. In current paper two problems are addressed, minimal distance to travel chosen pilgrimage places Andhra Pradesh, and also minimum distance needed to travel all state capital cities in India.**

***Index Terms*—Ant-Colony Optimization, Travels & Tours, State capitals, pilgrimage.**

I. INTRODUCTION

Travel & Tours industry is an industry with significant scope for better planning & scheduling so that the cost operation can be reduced and also fuel consumption connected population can be minimized. Planning a tour which include many places is challenging task to perform manually as there is possibility of numerous permutations and combinations.

II. ANTI COLONY OPTIMIZATION

Ants use a systematic method connecting nest with food, the Ants can find out the shortest path from the source to destination i.e., from the nest to food. Ants are visually challenged so they cannot use any visual cues. They will communicate with the help of chemical, named as PHEROMONE. Ants deposit some pheromone when they travel. More the pheromone trail on the path will give the best path (shortest distance). A computational approach is developed to mimic this process called as ant colony optimization. Ant colony algorithm is taken as one of the high performance computing methods for solving the Traveling salesman problem (TSP). Travelling sales person problem is applied to the closed graph. With the help of ant colony optimization applying to the TSP, Ants will travel across the closed graph in order to visit all the nodes exactly once in the graph. Budi Santosa[1] explained the process of developing ACO for TSP. Zar Chi Su Su [2] proposed modified ant colony algorithm for solving travelling sales man problem based on these two papers, two practical problems in Tours and Travels industry are chosen.

Placing the ants at different nodes and starting from a particular node for an ant k, to generate the path. And then apply the same process for the other ants so each ant will generate some path. If the path generated by an ant is already generated by another ant then it is rejected and new path generation is applied for the same ant again.

1. Pass the distance matrix as an input.
2. Read the number of ants to travel.
3. Place the ant at a specified city to start the tour.
4. For each ant,
    - Calculate the possibility of a city to visit.
    - Choose the not yet visited city until the tour is completed successfully.
    - Optimize the tour.
    - Update the pheromone level.
5. Evaporate Pheromone.

III. ALGORITHM DEVELOPMENT

Ants will take left and right by taking the decision. The decision taken by an ant is a random

decision. They produce more pheromone on the shorter path. The difference between two paths produced by ants over time, the ants choose the shorter path. If more ants are traveled through the path then the pheromone released by ants is more, that sign of the path indicate the best path. By taking each ant its own decision in order to generate a path, the ant should not repeat any path again. There generating number of different paths is increasing. So the possibility of getting the best path is more. Ant k at some node R will choose the destination S with having some probability. We calculate the possibility to visit other cities from city 1 using the formula of,

$$p_k(r,s) = \begin{cases} \tau(r,s)^{\alpha}\eta(r,s)^{\beta} \Big/ \sum_{u \epsilon M_k} \tau(r,u)^{\alpha}\eta(r,u)^{\beta}, & if\ s \epsilon M_k \end{cases}$$

Where pk(r, s) is probability move from city r to city s of ant k, τ is pheromone level, η(r, s)
is the visibility of cities r and s, and Mk set of cities possibly visited by ant k, α is the weight of pheromone τ and β is the weight to control visibility. Using α=1 and β=2.

If we are finding the probability of ant going from city1 to all cities then we use the formula,

$$p_1(1,s) = \tau(1,s)^1\eta(1,s)^2 / \Sigma\tau(1,s)^1\eta(1,s)^2$$

With the available probabilities, we will calculate the cumulative numbers of these probabilities. After that we will generate a random number, the random number is in between zero and one. We can have a natural random number by multiplying the original random number with 10. Later the random number is compared with cumulative numbers of each city. Whenever the random number is just above the cumulative number of a city let X, then the city X is visited. Then the city X is marked as visited, so the city X should not visit once again in the same tour. Now the tour is started from city X to the next city. Like that the tour is continued until all the cities are visited. Once tour is successfully completed for an ant, then the path of visiting cities is taken in order to find the tour length or distance travelled by an ant. The path along with length of the tour is stored in the memory. Then the 2nd ant will start the tour in the same way. Now the tour is start for the 2nd ant, above procedure is applied and path is generated. Now 2nd ant path is compares with the 1st ant path. If both the paths are identical then the path generated by the 2nd ant will be rejected. The 2nd ant will take the tour once again and generate a new path. Generated path is compared with the 1st ant path if both the paths are different then the 2nd ant path with length of the tour is stored. Now next ant tour will starts. This process is continued until, all the ants generate the paths successfully. The chemical released by an ant, pheromone is updated using the formula,

$$\tau_{r,s} \leftarrow (1-\rho)\tau_{r,s} + \sum_{k=1}^{N} \Delta\tau_{r,s}^{k}$$

Consider an initial pheromone on the path is 1. Then the evaporation of a pheromone and updating the pheromone trail is done by using the above formula.

Pheromone update is taken by considering the inverse tour length. For each tour the pheromone is updated. By comparing the Pheromone on the path, the best tour is selected with the minimum distance (cost/length).

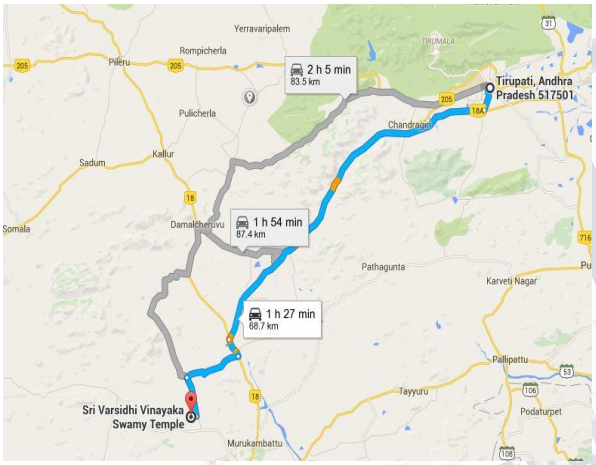
The number of ants can generate the path using the condition, the ants should be lesser than the factorial of cities -1 i.e., factorial(n-1). Where, n is the number of cities.

The distances taken in a matrix passed as input to the system. System will store all the distances in a symmetric matrix. Because, the distance between the city X to city X is 0. Its represents the diagonal matrix is zero. Whenever we are talking about the visibility matrix we will consider the diagonal matrix of a visibility matrix is also zero. Above procedure is done on visibility matrix. City X is marked as visited by making zeros of X column in visibility matrix. Process is continued till the visibility matrix become the null.

IV. PILGRIMAGE IN ANDHRA PRADESH

Popular pilgrimages in Andhra Pradesh are chosen to apply the algorithm to find the shortest path among them. In ANDRA, there are many famous temples. Each temple has its own faith. Different pilgrimages in ANDHRA are Annavaram, Srikalahasti, Thirupathi, Srishailam, Draksharavam, Antherwedi, Kanipakam, Mahanandhi, Yaganti, Bhadrachalam, Vemulawada, Warangal and more.

Usually people want to visit all these temples with a minimal cost with less time in an optimal way. A tours & travels company which is not belonging to the ANDHRA, then they may know all the places but they may not aware of which temple we should visit first and travels to the next temple from a temple, this procedure is continued till the end of the tour. So they can minimize the tour length. The cost of the tour is depends on the length of the tour and the time taken by the tour. By applying Ant colony optimization to the tours and travels we can reach the above requirements. Because of minimal length of tour, the cost is reduced to some extent. And time taken by the tour is also get reduced. The burden in term of money and time on the customers is less, so they can have a thought to visit the temples after some period of time again with the same tours and travels company.



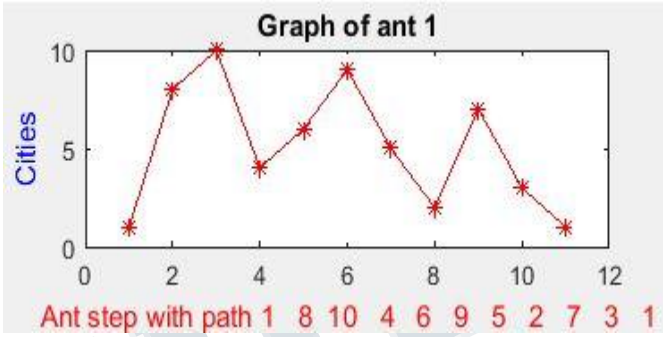
The above map is showing the rout from tirupathi to kanipakam temple with distance. In the same way, consider different places with distances.

Ants use a systematic method connecting nest with food, the Ants can find

- Hyderabad
- Warangal
- Kanipakam
- Bhadrachalam
- Vijaywada
- Dharmapuri
- Vemulawada
- Tirupathi
- Srikalahasti
- Srisailam

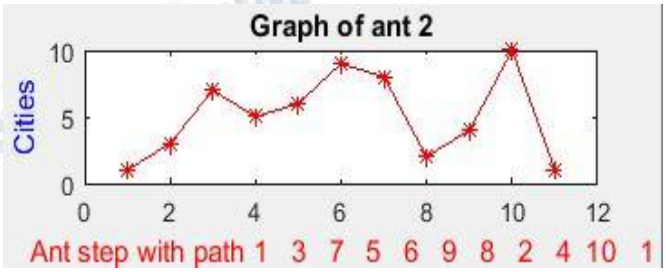
Ant 1

The below graph is a tour of 10 cities.



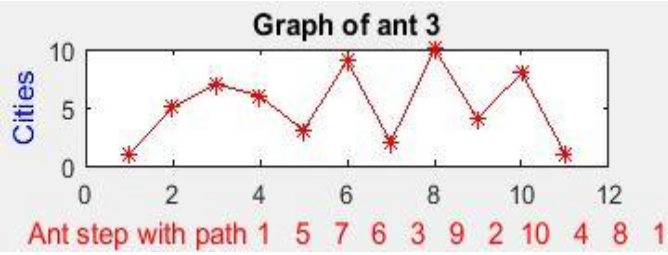
It is a graph of 1st ant that is predicting the path to visit different cities. From the above graph it is advising to travel from 1st city to the 8th city like that the tour is visited in the path 1-8-10-4-6-9-5-2-7-3-1. This is the way, tour is chosen by the 1st ant.

Ant 2

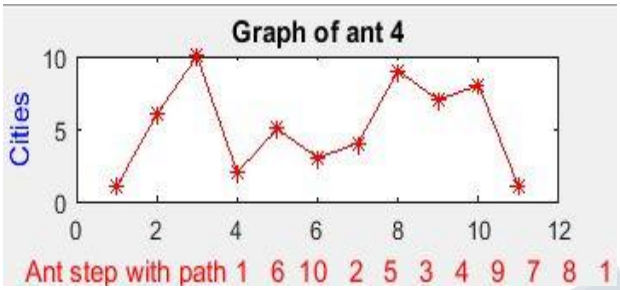


2nd ant is chosen the path like 1-3-7-5-6-9-8-2-4-10-1. This indicating, the 2nd ant is chosen different path as compared with 1st ant. Like this way each and every ant will choose the different paths. The graphs produced by remaining ants are,

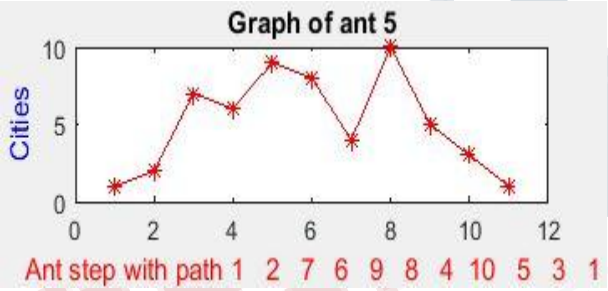
Ant 3



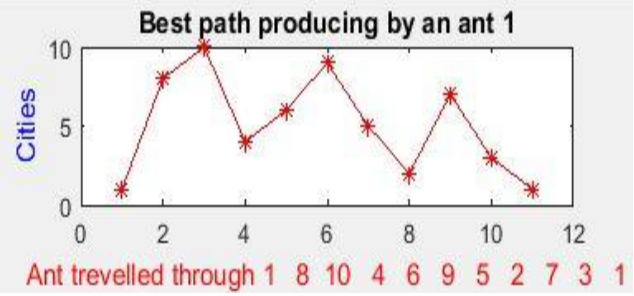
Ant 4



Ant 5



These graphs are produced by 5 ants travelling by 10 cities. From the above graphs each ant is chosen different path. From all the paths generated by ants the best path is chosen by an ant is,



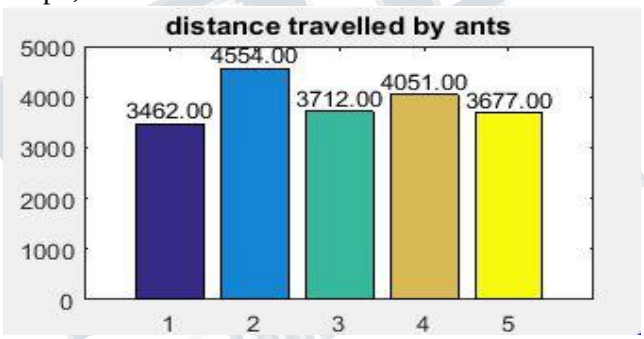
Distance travelled by an ant with path is,

```
the totoal available paths are
     1     8    10     4     6     9     5     2     7     3     1
     1     3     7     5     6     9     8     2     4    10     1
     1     5     7     6     3     9     2    10     4     8     1
     1     6    10     2     5     3     4     9     7     8     1
     1     2     7     6     9     8     4    10     5     3     1

best path is
     1     8    10     4     6     9     5     2     7     3     1

the minimum length of path is
        3462
```

The above paths are generated by all the 5 ants and among all the 5 paths the best path (which will represents the shortest distance) is selected with the minimum distance. The graphical representation of each ant path with distance is shown with a Bar Graph,



V. STATE CAPITALS

A tour is conducted in order to visit all the state capitals in INDIA, with the shortest distance. We don't have an algorithm which will tell us that, choose a particular path to complete the tour in an optimal way. Solve this kind of problem, where we should travel across INDIA with the shortest distance to cover more places with less time with less cost. This type of problems are raised for, who wants to travel more places with in the less time and money.

Consider a tour of any 5 cities, from city one I can visit any one of the other cities like that the cities I may visit like 1-2-3-4-5-1 or 1-3-2-5-4-1 or 1-5-2-4-3-1 and so on.

Here like this we can get 24 different paths to visit all the 4 cities from a starting city1.

From the above, 1 is the starting city and after visiting remaining 4 cities, we should come back to the starting city 1.

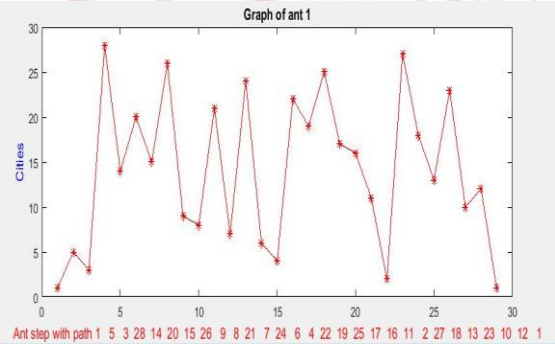
Imagine a case where we have to visit 20 or more than 20 cities, let the number be n where n>20 then the number of possible ways to visit all the cities are a big number. For 20 cities it is equals to (20 factorial)-1. i.e., 2.4329e+18. This is an exponential representation of a number.

If someone wants to visit all the states capitals in INDIA. There are 29 states in INDIA. In this case the total number of available ways to visit all state capitals in INDIA are very huge. To avoid such situations in real life, we can apply an ANT COLONY OPTIMIZATION ALGORITHM for TOURS & TRAVELS.

Let, the travels is belong to the one of the state capital in INDIA, the states around the travel city may the travels know the best rout, however they are not aware of visiting different states of long distances. To visit state capitals with longer distances will raise the complexity. The order in which they are visiting is more important.

Ant 1

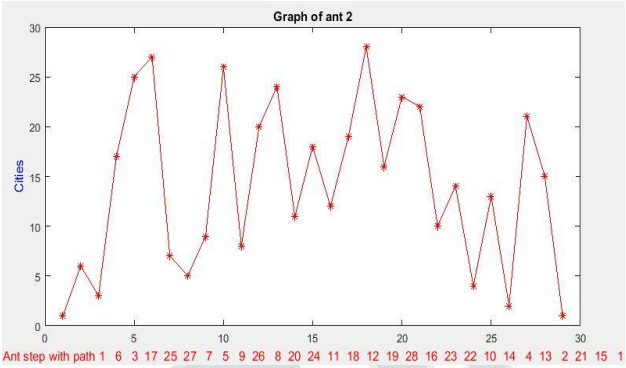
The below graph is a tour of 28 cities in INDIA. All cities are state capitals. The tour of ant1 with all state capitals in INDIA given a tour,



Ant 1 tour is completed then tour for ant2 will start.

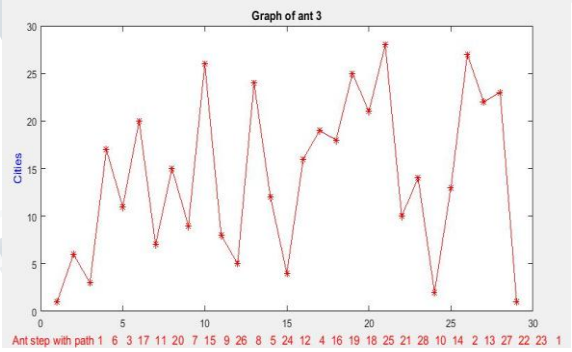
Ant 2

Graph is generated with a condition of generating unique path, such that the generated path of ant 2 is compared with the ant1. If ant1 and ant2 paths are different, then the graph is



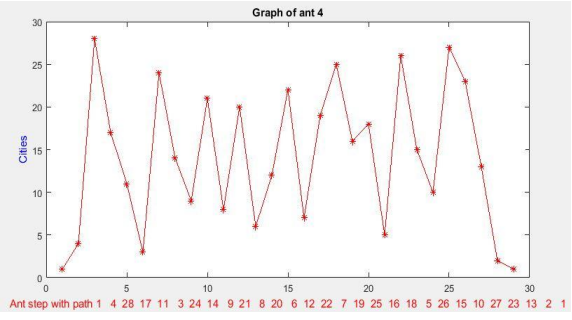
Ant 3

Graph generated by ant3 will compared with all the paths generated previous ants. If it is different then the graphical representation of a path is as follows.



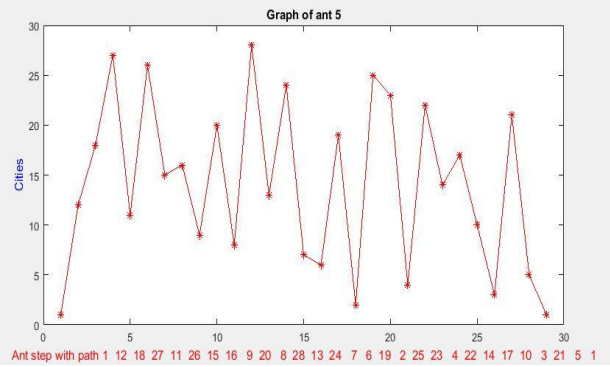
The points (starts) indicate the state capitals. The state capitals are taken along with the Y-axis and the X-axis is an step.

Ant 4



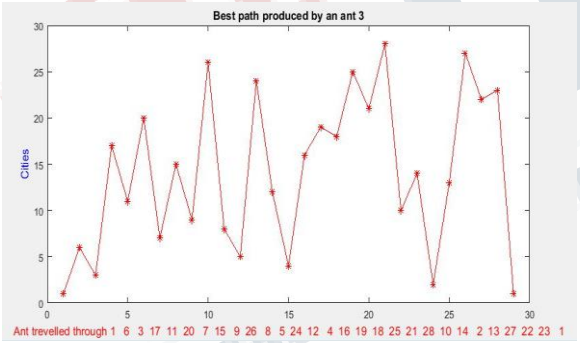
The graph indicating the path with respect to the ant4. The numbers on the X-axis followed by ant step with path are indicating the city number to visit. The graphical representation of path for ant5 is as follows.

Ant 5



We gave input as 5 ants, that is the number of ants to travel. Above five graphs are showing the paths all five ants with order of the path the ants are visited.

From all the five ants an ant is selected which is generated the best tour, that is the tour with minimal cost. The best tour is generated by the ant is,



From the above graph the best path is generated by the ant 3 and the path of ant 3 is visited.

The different paths generated by all the ants are,

```
the totoal available paths are
  Columns 1 through 18

    1     5     3    28    14    20    15    26     9     8    21     7    24     6     4    22    19    25
    1     6     3    17    25    27     7     5     9    26     8    20    24    11    18    12    19    28
    1     6     3    17    11    20     7    15     9    26     8     5    24    12     4    16    19    18
    1     4    28    17    11     3    24    14     9    21     8    20     6    12    22     7    19    25
    1    12    18    27    11    26    15    16     9    20     8    28    13    24     7     6    19     2

  Columns 19 through 29

   17    16    11     2    27    18    13    23    10    12     1
   16    23    22    10    14     4    13     2    21    15     1
   25    21    28    10    14     2    13    27    22    23     1
   16    18     5    26    15    10    27    23    13     2     1
   25    23     4    22    14    17    10     3    21     5     1

best path is
  Columns 1 through 18

    1     6     3    17    11    20     7    15     9    26     8     5    24    12     4    16    19    18

  Columns 19 through 29

   25    21    28    10    14     2    13    27    22    23     1

the minimum length of path is
       39304
```

The above graph is indicating the five ants paths and the best path from all the five ants with the distance covered by that path.T he numbers what we are capable of showing on the graph are the city number s. This can also predict the path not only the visiting cities in the number format but also as cities. The cities with the best tour will to be printed as,

```
'Andhra Pradesh(Hyd)'
'Goa(Panaji)'
'Assam(Dispur)'
'Meghalaya(Shillong)'
'Jharkhand(Ranchi)'
'Odisha (Bhuvaneshwar)'
'Gujarat( Gandhinagar)'
'Maharashtra(Mumbai)'
'Himachal Pradesh( Shimla)'
'Uttarakhand( Dehradun)'
'Haryana(Chandigarh)'
'Chhattisgarh(Raipur)'
'   Tamil Nadu(Chennai)'
'Karnataka(bangalore)'
'Bihar(Patna)'
'Manipur( Imphal)'
'Nagaland(Kohima)'
'Mizoram(aizawl)'
'Tripura( Agartala),'
'Punjab(chandighar)'
'   West Bangal(kolkatha)'
'Jammu and Kashmir(Srinagar (summer) or Jammu (winter))'
'Madhya Pradesh( Bhopal)'
'Arunachal Pradesh(Itanagar)'
'Kerala(Thiruvanantha puram)'
'Uttar Pradesh(Lucknow)'
'Rajasthan(jaipur)'
'Sikkim( Gangtok)'
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The above cities are in the order, that best tour is generated. The tour is started with the city Andhra Pradesh which is chosen as an initial (first) city and the last visited city is Sikkim (Gangtok) according to the path.

VI. CONCLUSION

Ant colony algorithm is a successful method to apply, to the *Tours & Travels* problem. To find the shortest distance between the cities and visit all the cities exactly once to reach the requirements of the customers we can use an ant colony algorithm. In this paper an attempt is made to apply ACO algorithm for Pilgrimage and also for visiting state capitals. The accuracy of the results can be further improved by choosing more number of ants. Using this algorithm Travel Agencies can minimize fuel consumption, operating cost, waiting time etc.

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