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Ant Colony Optimization is the limited case of Prim's Algorithm

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Abstract- Swarm intelligence has the capability to recover path with minimum complexity. It only needs small amount of some special purpose information aside from probability information, we can have the value of alpha equal to zero and beta equal to one. So pheromone distribution although is a key feature for discovering minimum path by ants. When I was working on "ACO" I found that changing constraint little bit makes the probabilistic determination of path work only with its component and in this case it is visibility. As its impact is on the distance chosen which can be easily derived as some kind of heuristic such as Manhattan distance or here the distance between two nodes. As there could be case that in case of minimum spanning tree with only single edge originating from a vertex ant gets its final position at the last vertex and in that case from the idea of "aco" we can reach Prim's but with limitation and that's why the name that "aco is limited case of Prim's".

General Terms- Pheromones, visibility, probability, spanning tree.

1. INTRODUCTION

Systems biology of decision making focuses on understanding the structures, dynamics, and evolution of complex interconnected biological mechanisms that support decision making by individuals and social animal groups. In this talk, an experimentally validated mathematical model of the nest site selection process of honey bee swarms is introduced. In this spatially distributed dynamical feedback process individual bee actions and bee-to-bee communications combine to produce an emergent "consensus" nest choice. The process has connections to neurobiological cognition systems, especially at the behavioral level: the swarm can effectively discriminate between different quality nest sites and eliminate from consideration relatively inferior distracter sites.Swarm intelligence is an emerging field of biologically-inspired artificial intelligence based on the behavioral models of social insects such as ants, bees, wasps and termites. Swarm intelligence is a scientific theory about how Complex and sophisticate behaviors can emerge from social creature group.

ACO (Ant Colony Optimization):- The first algorithm was aiming to search for an optimal path in a graph, based on the behavior of ants seeking a path between their colony and source of food. The first ant finds the food source via any way then returns to nest and leaving behind a trail of pheromone. Other ants follow the different ways and make a path more attractive as the shortest route. Shortest path will be increasingly enhanced and long paths will eventually disappear because pheromones are volatile.

Prim's algorithm is a greedy algorithm that finds a minimum spanning tree for a connected weighted undirected graph. This means it finds a subset of the edges that forms a tree that includes every vertex, where the total weight of all the edges in the tree is minimized. We consider a weighted connected graph G with n vertices. Prim's algorithm finds a minimum spanning tree of G.

Procedure Prim (G: weighted connected graph with n vertices)
T: = a minimum-weight edge. For i = 1 to n − 2
begin
e: = an edge of minimum weight incident to a vertex in T and not forming a circuit
in T if added to T
T: = T with e added
End
return (T)

2. PROBLEM DEFINITION

We can reach "Prim's" from the idea of "ant colony optimization algorithm". The result given by "Prim's" with a single edge originating from a vertex can be obtained.

2.1 Problem Formulation

Movement of ant from one vertex to another vertex is given by probabilistic estimation given below:

$$P^k xy(t) = [\tau xy(t)]^{\alpha} . [\eta xy(t)]^{\beta} / \sum [\tau xy(t)]\alpha . [\eta xy(t)]\beta$$

where $\alpha >= 0$ and $\beta >= 1$

After imposing constraint it is reduced to:

$$P^k xy(t) = 1 . [\eta xy(t)]^1 / \sum 1 . [\eta xy(t)]1$$

where $\alpha = 0$ and $\beta = 1$

So if x and y is initial and final nodes of a graph then an ant starting from a node x could reach node y with highest probability.

Since probability is highest for an ant to move from one vertex to another so if we take heuristic for visibility as reciprocal of distance with other constraints then an ant can move with the higher value of visibility alone given by:

$$\text{Visibility } (\eta) = 1/d$$

So, if the ant moves with the greater value of visibility alone then the result obtained is similar as if obtained by "Prim's" but with some limitations.

2.2 Aco Algorithm

Many species adaption genetic algorithms have been proposed and "Swarm Algorithm" is among one of them. This algorithm was developed by observing ant colonies

and is an approximate algorithm. The computational agent in this algorithm is an ant. The two key variables which help in deciding the correct route are ηxy and τxy. ηxy gives the attractiveness of the move and is given by some heuristic defined in accordance with the problem definition. It is also called as visibility. τxy gives the proficiency of the move which took place in the past. It indicates the pheromone level. ηxy and τxy are controlled by two parameters α and β and helps in determining the probability to select the next vertex. The movement of the kth ant from state x to state y is given by:

$P^k xy(t= [\tau xy(t)]^{\alpha} . [\eta xy(t)]^{\beta} / \Sigma[\tau xy(t)]\alpha . [\eta xy(t)]\beta$

where α>=0 and β>=1

2.3 Aco Algorithm As A Limited Case Of Prim's Algorithm

i. Reciprocal of the distance between the edges is choosen as a heuristic for defining η. Hence visibility is given as:

1. $\eta = 1/d$.

ii. With α=0, there is no influence of pheromones on computing probability.

iii. With β=1, it controls the visibility and distance between vertices has full influence on the choice.

iv. An ant is placed at the starting node and is allowed to move the edges with higher probability.

v. When α=0 and β=1 , the probability determining formulae reduces to

$P^k xy(t) = 1 . [\eta xy(t)]^1 / \Sigma 1 . [\eta xy(t)]1$

where α=0 and β=1

vi. Now visibility is giving the value for selecting nodes instead of probability.

vii. For every value of greater visibility there is highest probability to move to the next vertex.

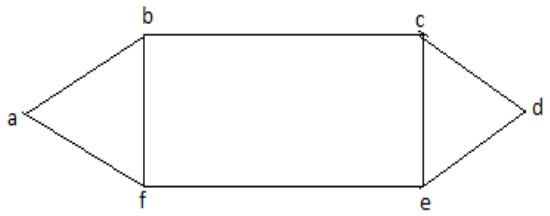


fig.1 undirected graph

Table1:Visibility calculation for the ants at each vertex

EDGES	WEIGHT	VISIBILITY
A-B	5	0.2
A-F	10	0.1
B-F	2	0.5
B-C	8	0.125
F-E	3	0.33
C-E	6	0.17
C-D	1	1
E-D	4	0.25

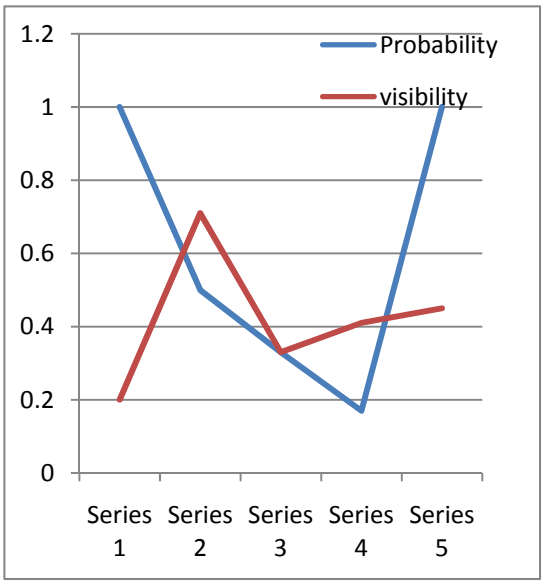
2.4 Probability Vs Visibility

After calculating the values of visibility and probability, we can conclude that they give the same pattern if shown by the graph.

Table2: Visibility and probability calculation

EDGES	VISIBILITY	PROBABILITY
A-B	0.2	1
B-F	0.5	0.71
F-E	0.33	0.33
C-E	0.17	0.41
C-D	1	0.45

Graph1:Pattern of visibility and probability



2.5 Constraints Taken

i. Although an "ANT COLONY OPTIMIZATION ALGORITHM "gives the minimum path here the consideration is that after reaching the destination all those vertices will be covered which has maximum visibility.

ii. There should not be any loop.

iii. α=0 and β=1 (As α is equal to zero and there is a single ant so there is no need to update pheromones or keeping in account the decay rate of pheromones.)

iv. A single vertex can't have more than one edge.

CONCLUSION

Swarm intelligence has the capability to recover path with minimum complexity. It only needs small amount of some special purpose information aside from probability information and what I found after going through research papers and Wikipedia is that we can have the value of alpha equal to zero and beta equal to one. So pheromone distribution although is a key feature for discovering minimum path by ants, if we consider as not volatile then in my perspective any formulation can be molded to get something new which is a part of research.

When I was working on "ACO" I found that changing constraint little bit makes the probabilistic determination of path work only with its component and in this case it is visibility. As its impact is on the distance chosen which can be easily derived as some kind of heuristic such as Manhattan distance or here the distance between two nodes. What I found is that when there would be single ant and if there would not be any loss of pheromones then the route discovered will be unique. When I worked on it I found the minimum distance which was nothing new as it is what "aco" is all about. But I found that if I extend the tour further for the vertex with high visibility and by checking for loops so that convergence can be avoided I found the working similar to that of Prim's.

My extension to this is only the consideration that the ant moves further after reaching the goal for the vertex that has higher visibility. As there could be case that in case of minimum spanning tree with only single edge originating from a vertex ant gets its final position at the last vertex and in that case from the idea of "aco" we can reach Prim's but with limitation and that's why the name that "aco is limited case of Prim's".

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