Eternity's Team Description
Robocup Rescue Simulation

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Introduction

The RoboCup Rescue Simulation domain [1] , is a challenging multi agent environment , in witch tasks need to be assigned collaboratively to different types of agents . In this domain, achieving the main goal requires adaptive high performance Cooperation of several agents . The challenging problems in Rescue Simulation are:

- Lack of information from the environment (Only local information is available for each agent).
- The dynamic environment makes the available information unreliable after a period of time
- Communication between the agents is limited , so its precious to transmit as much data as possible in low size messages.

These problem lead us to design an adaptive, stigmergetic and cooperative system based on Ant Colony Optimization (ACO). The main idea behind our system is inspired from AntNet originally proposed by M.Dorige and G.dicaro in 1997. In AntNet routing, a group of mobile agents (or artificial ants) build paths between pairs of nodes exploring the roads network concurrently and exchanging obtained information in order to update the routing tables.

The traditional routing methods do not have enough flexibility and adaptivity in dynamic environments like Rescue simulation .

Ant Colony Routing Algorithm

In the Ant based routing algorithms,routing is determined by means of very complex interaction of forward and backward city roads network exploration agents (Ants). The idea behind this subdivision of agents is to allow the backward ants to utilize the useful information gathered by the forward Ants, on their trip form source to destination. Suppose we have N nodes(in the city roads network),where s denotes a generic source node, when an agent(Ant) is generated toward a destination d, from this node. Two types of ants are explained:

- Forward Ant ,denoted $F_{s \rightarrow d}$,which travels from the source node s to destination d.
- Backward Ant ,denoted $B_{s \rightarrow d}$,will be generated by a forward ant $F_{s \rightarrow d}$ in the destination .It will come back to s following the same path traversed by $F_{s \rightarrow d}$,

with the purpose of using the information already picked up by $F_{s \rightarrow d}$ in order to update routing tables of the visited nodes.

Every ant transports a Stack $S_{s \rightarrow d}(k)$ of data , whether k index refers to the k_{th} visited node , in a journey, where $S_{s \rightarrow d}(0)=s$ and $S_{s \rightarrow d}(m)=d$ being m the amount of jumps performed by $F_{s \rightarrow d}$ for arriving to d. Let k be any network node; its routing table will have N entries, one for each possible destination.Let j be one entry of k routing table (a possible destination) and Let N_k be set of neighboring nodes of node k. Let P_{ji} be the probability with which an ant or data packet in k, jumps to a node i, $i \in N_k$, when the destination is j (j <> k). Then, for each of the N entries in the node k routing table , it will be n_k values of P_{ji} subject to the condition:

$$\sum_{i \in N_k} P_{ji} = 1 \mbox{ ; } 1 \leq \forall j \leq N.$$

The routing table and list of trips updating methods for k are described as follows: Routing table of node k is updated for the entries corresponding to all nodes k' between k and d inclusive. For example, the updating approach for the d node, when $B_{s \rightarrow d}$ arrives to k, coming from f, $f \in N_k$ is briefly explained, as following:

- A P_{df} probability associated with the node f when it wants to update the data corresponding to the d node is increased, according to:

$$P_{df} \leftarrow P_{df}+(1-r')*(1-P_{df}).$$

where r' is an a dimensional measure, indicating how good (small) is the elapsed trip time T with regard to what has been observed on average until that instant. Experimentally, r' is expressed as:

$$r' = \frac{T}{c\mu} \mbox{ (c $\geq$ 1 if $\frac{T}{c\mu} < 1$) Or 1 o.w}$$

where: μ is average of the observed trip-time T ;
and. c is a scale factor experimentally chosen as 2 [2].
More details about r' and its significance can be found in [2].

- The other neighboring nodes (j <> f) P_{dj} probabilities associated with node k are diminished, in order to satisfy equation (1),through the expression:

$$P_{dj} \leftarrow P_{dj}-(1-r')*P_{dj} \mbox{ $\forall j \in N_k, j \neq f$}$$

A list $trip_k(\mu_i,\sigma_{i}^{2})$ of estimate arithmetic mean values μ_i and associated variances σ_{i}^{2} for trip times from node k to all nodes i i <> k is also updated. This data structure represents a *memory* of the network state as *seen* by node k . The list trip is updated with information carried by $B_{s \rightarrow d}$ ants in their stack $S_{s \rightarrow d}$.For any node pair source-destination, μ after (n+1) samples (n>0) is calculated as follows:

$$\mu_{n+1} = \frac{n\mu_n + x_{n+1}}{n+1}$$

where: x_{n+1} trip time T sample n+1, and μ_n is the arithmetic mean after n trip time samples.

Going to the detail of our system we describe the system in two stages:

The Two Stages

Stage I

This stage is devoted to the first cycles of the simulation. At the beginning of simulation each agent's data is local; therefore the agent has a raw data about the global environment. After some cycles, each agent gathers more information about it's region.This is why we separated our strategy into two stages.

We Propose some roads as "good" roads. These strategic roads are used by different agents during the simulation as representative compact characteristics of each region used in agents for routing.

For Finding these "good" roads we use an Ant Colony based algorithm in each agent. For this purpose we compute the average of probabilities of entrance into each road *in the routing tables updating by the routing system*; then "good" roads are defined as roads with highest average.

Police Forces consider high priority for clearing these roads. As the raw and basic information of agents about the unknown regios are nearly the same, "good" roads chosen by different agents are similar. Therefor if police forces clear these roads then the other agents can use them easily.

The other usage of "good" roads appear when an agent wants to go across a region and hasn't enough updated information about that region to use an ant based routing.

Each agent use it's specific region as the domain of Ant based routing with some modification s which are:

- At regular intervals, each agent produces virtual ants lunched from several nodes of its region r, also the ants destinations are selected inside r.
- In the original AntNet algorithm ,the trip time of each virtual ant,was the effective factor for updating the routing tables. In our system each virtual ant A computes it's own trip time as a function defined below :

$$T_{trip}(A) = \sum_{R \in A's \mbox{ } path} T_{road}(R) \mbox{ ;in which A is an Ant}$$

$$T_{road}(R) = \frac{\alpha}{PLH(R)} + \frac{\beta}{d(R)}$$

Where PLH(R) is the number of lines to the head of road R, which are passable; obtained from the formulas listed below (extracted from RCRSS Manual Ver 1.0 [1]) :

$$lineWidth = \frac{width}{linesToHead+linesToTail}$$

$$blockedlines = \lfloor \frac{block}{2.lineWidth}+0.5 \rfloor$$

$$passableLinesToHead = max(0, linesToHead - blockedLines)$$

$$passableLinesToTail = max(0, linesToTail - blockedLines)$$

in which d(R) is the distance of road R from the nearest fire site.

also alpha and beta are coefficients showing the importance of each factor (PLH(R) and d(R)).

In this stage ,in each region the policeforces try to clear some good roads which are likely to form a spanning tree in the region. The main benefit behind this idea is : The roads selected for clearing in this stage are more probable to be used by other agents in the next cycles of simulation ,when they want to go across the region .

We found out that ambulance team agents don't need to change their region frequently, so we selected this type of agent as the storage place, where the information of one region is stored for the usage of requesting agents.

Every time an agent wants to pass across a region (which is not it's own region) the ambulance in that region transmits the good roads of the region to that agent; in case the connection between them can't be be established (because of far distance or high communication load between agents) the agent applies the Ant based routing with it's raw information from the region .

Stage II

After clearing good roads by police forces, the second stage begins .

In this stage each agent, at each time, may have a destination node d .

if d is in it's own region , the agent uses ant based routing by it's uptodate information of the region. Otherwise suppose d is in region r_d, the agent asks it's center for sequence of regions, starting from it's own region to region r_d .The center agent outputs the requested path by means of a simple routing Considering the region's and the roads connecting them in the map . After getting the path, the agent crosses the regions in the path one by one; for this purpose,the agent requests the ambulance which is responsible for the region in order to send it a suitable route through the region and also a list of good roads described before. The agent uses these good roads when the route is not passable at the time agent wants to pass (unreliable data). it is notable that "good" roads are not fixed (because the environment is dynamic) but updateing by the ambulances frequently. These updated "good" roads are then transmitted to policeforces without any specific destination(wandering polices without any critical task) , so that they can clear these new roads for future usage .

References

- ✓ [1] Takeshi Morimoto - edited by RoboCupRescue Technical Committee : How to Develop a RoboCupRescue Agent for RoboCupRescue Simulation System Version 0.1st edition(2002).
- ✓ [2] M.Dorigo, G. Di Caro : AntNet.Distributed Stigmergetic for Communication Networks. Journal of Artificial Intelligence Research. Vol. 9 (1998)
- ✓ [3] Gianni Di Caro, Marco Dorigo : Two Ant Colony Algorithms for Best-Effort Routing in Datagram Networks
- ✓ [4] I.Kassabalidis, M.A, E1-Sharkawi, R.J.Marks II, P.Arabshahi, A.A.Gray : Swarm Intelligence for Routing in Communication Networks
- ✓ [5] Y.Yang, A.N.Zinicir-Heywood, M.I.Heywood, S.Srinivas : Agent-Based Routing Algorithms on a Lan
- ✓ [6] Benjamin Baran , Ruben Sosa : AntNet Routing Algorithm for Data Networks based on Mobile Agents (2000)