Team Description of S.O.S.

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Abstract. This paper contains a brief overview of the algorithms and methods used in the design process of S.O.S. agents. Our emphasis while designing was to make efficient use of data mining algorithms and utilizing complexity management methods to analyze the problems and finding appropriate solutions.

1 Introduction

RoboCup Rescue Simulation, as a multi-agent system, has unique properties which make it different from the other popular multi-agent domains. One of these unique properties is the concept of plan-like actions. Basic actions that can be done by agents are more like plans rather than atomic actions, i.e. the agent, deciding to do a specific action, must check several pre- and post-conditions and trace over the plan during several time steps to complete the action successfully.

We think that, this is one of the most important reasons why developing responsive cooperative agents to act in RoboCup Rescue Simulation Environments is a difficult task. Agent developers, while designing and implementing agents, should keep track of their agents' tasks from several layers of abstraction, varying from long-term plans and strategies to simple condition checking layers to do a specific action and unfortunately, there is a high possibility for them to make mistakes or to get confused.

In this paper, we will describe the methods we used, while designing our rescue agents, to solve this problem. In the following sections, we will describe problems concerning different aspects of decision-making process and our solutions to each problem.

2 World Modeling

The first step toward managing and overcoming the complexity of the disaster environment is to deal with the lack or abundance of data. We have used several data mining methods and algorithms to convert large amounts of data to small pieces of valuable high-level information and also to predict missing data values.

In our approach to deal with the missing data a value is estimated for each changing attribute based on internal parameters and weights by the agents. There is also a reliability factor for possible values of each attribute which specifies the probability of the attribute having a specific value in the given condition.

These pieces of high-level information are very useful for agents to make successful decisions in various situations, because the agent, using a predicted value and the reliability factor for that value together, can approximate a reliability factor for its decisions which is an appropriate criteria for determining the priority and value of the actions.

Our world modeling method is also adaptive, that is when a real sense is made the approximated value for any sensed attribute is compared with the real value and the internal weights are modified to adapt to new values set.

3 Fire Brigades

One of the most important aims of the rescue team in the first steps of simulation is to prevent fire from spreading to other buildings and to find and eliminate the initial fire sources as soon as possible. Problems concerning the task of fire brigades are searching for fiery buildings, determining the priority of them to extinguish and cooperating efficiently with each other to extinguish them.

Searching for new fiery buildings is of remarkable importance, because of the fact that the sooner the agents can find and eliminate fire sources, the more chance they will have to extinguish it and to prevent it from spreading fire. To solve this problem in the first steps of the simulation, we used a cooperative search method by heterogeneous agents.

We also designed and implemented an internal fire simulator which is used to simulate the spread of fire among the buildings. The IFS takes as its input the characteristics of a fiery building and the buildings near it and the number of extinguish actions performed on it, and predicts the fieryness of that building and its neighbors in the next few states. Once finding the initial fire sources our main focus is on simulating the fire behavior and predicting the new fiery buildings at each step.

Another problem we dealt with was the priority of fiery buildings. To prioritize fiery buildings, our agents first try to prioritize the initial fire sources, selecting a subset of them. Priorities to sources are given based on several factors such as the effort needed to eliminate the fire source, its accessibility and the effect of ignoring it. After selecting fire sources with the highest priorities, agents are assigned to the sources using a method based on Weighted Matching algorithm. After being assigned to a source, agents each time try to find the fiery building with the highest priority around that source and extinguish it. This priority is computed using parameters such as distance from the agent, fieryness, area, being in the boundary of the fire region, urgency, etc.

At last, the most important problem is cooperation between agents. It's obvious that assigning both more or less number of fire brigades needed to extinguish a fiery building, to that building is a waste of resource. Keeping this fact in mind, many team last year, modeled this problem with a Resource Allocation problem. As the first solution we also concentrated on a similar approach, but with a significant change which is its decentralized nature. Another important subject making the cooperation more important is the limitations applied to tank capacity of fire brigades in 2003 Rules, as the second result of a well-cooperated extinguish task, after extinguishing fire sources efficiently, is the minimized decrease in the amount of water used by each agent.

In the case of a brigade having no more water, it suspends its current mission, going to the nearest refuge to fill its tank. Here another important problem takes place, which is how long should that brigade stay in that refuge. Our fire brigades after reaching a refuge, at each step approximates the status of the disaster environment, taking into account parameters such as the number of new fiery buildings, number of civilians alive, total area of the regions under fire and the effectiveness of the brigade's efforts. Measuring how critical the city status is and predicting how critical it would be in the next steps, the brigade decides whether to stay at the refuge or not.

4 Police Forces

Police forces play a key role in the disaster environment, for they make it possible for other agents to go to different places in the city to do their specific task, by opening the roads on their path which are blocked.

The main problem concerning the task of police forces is determining the order in which the roads should be opened. To prioritize the roads we first classified them into three major groups:

1. Roads along the path of agents to their targets.
2. Roads in an important region or location e.g. fire sources.
3. Geographically strategic roads.

To prioritize the roads based on the first criteria, each fire brigade or ambulance team, chosen a specific target, sends its target indirectly to police forces. Then police forces predict the selected path by that agent to its target and give priority to the roads along the path based on the situation. So the roads used by more agents for more important goals are the roads with higher priorities.

For determining the important regions we focused on factors such as density of civilians, regions near the fire sources and refuges; and for determining the strategic roads we used an effectiveness factor for each road in the paths used by agents. The effectiveness factor is computed offline by determining the length of all pair shortest paths between every node two times. The first time we considered the road open and the second time we considered it blocked. The difference between these two computed values is the effectiveness factor for that road.

5 Ambulance Teams

Major problems concerning Ambulance teams are finding civilians and preparing an efficient plan to rescue as many buried and injured civilians as possible. It's not correct that finding and rescuing civilians is the task of only ambulance teams as the number of ambulance teams is very small and it is almost impossible for these few number of agents to search the disaster space thoroughly. So the first idea which comes to mind is the idea of a cooperative search aided by heterogeneous agents. Fire brigades and police forces keep some information about the civilians needing help and transmit these pieces of information to the ambulance teams in a suitable time. The information transmitted contains the place where the buried or injured civilian has been found and the priority of that civilian. Using these priorities and the priorities the ambulance team itself sets for civilians, it chooses a civilian to rescue.

Actually, computing the priority of a buried civilian is a rather complex task, affected by a wide variety of parameters. For this task, we considered into mind various parameters such as civilian's buriedness, the condition of its place, its HP and damage value, etc. The goal is to give the higher priority to a civilian for which the benefit of rescuing per the effort needed to rescue that civilian is maximum. It can be seen that, if we define t as *the time it will take for an injured civilian to die*, the distribution of the priority function over the different value ranges of t is a normal distribution, which means that civilians with very high or very low t value are given the lowest priority.

For computing t we designed a neural network with four inputs and one output. The inputs of the network were the density of fire around the civilian's position, its HP, its damage and its buriedness and the output was t value for that civilian. We used a back-propagation algorithm for training the network and after training with about 4000 data sets the network seemed to have become stable and the values were approximated with an acceptable precision. Another proposed neural network is a network with three inputs and one output. The inputs of the network are density of fire, civilians damage and buriedness and the output is the civilians damage in the next step. We predict that learning the new function would be much easier for the network and using the output of the network, we can predict t with a better precision.

6 Conclusion and Future Works

This year, our main focus while designing agents was on making effective use of data mining algorithms to build a powerful knowledge base for our agents and to provide them with useful high-level information to make effective decisions. Our current and future works to improve agents' behavior includes designing some Reinforcement Learning algorithms and migrating the current agents into fuzzy, behavior-based agents. We are also documenting our agent software architecture which we believe is an excellent framework for designing planning agents for RoboCup Rescue Simulation. We are planning to make it available for public use, as soon as it becomes ready. We hope that the result of our researches will be useful for others interested in multi-agent systems, especially RoboCup Rescue Simulation domain.