Kshitij: Team Description

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Abstract. In this paper we describe the rescue team Kshitij. Our contribution to the rescue simulation league is in the following aspects: civilian rescue and exploration of the site. Some of our approaches are scalable and can be applied in very-large real-life situations. In the near future we plan to work on the low level tasks such as path planning, communication etc. and also on using dynamic learning for the agents.

1 Introduction

Robocup rescue simulation league [1] is modeled as an urban locality hit by an earth quake. The rescue simulation environment is similar to a real-life situation. The environment is dynamic and each agent has a partial observation capability. The agents are required to circulate the information they gather and make online decisions based on the available information. Agents consist of police forces, ambulance teams and fire brigade. These heterogeneous groups of agents need to be programmed to search the site, clear the blockades, rescue civilians and extinguish fires. Agents need to cooperate among themselves and co-ordinate their actions in order to increase the number of civilians and buildings that are saved. These methods could be applied for similar situations in real life.

In our work we try to develop good solutions for this problem. Specifically we develop methods that are scalable so that they can be applied in real-life situations. We used the resources provided by Morimoto [5] for the team development. In order to concentrate on high level aspects of the problem we used the code developed by ResQ Freiburg Team [2], which can be downloaded from the 2004 contest web-site.

Our contributions are as follows:

1. For civilian rescue we group civilians who are spatially close (we call this a civilian site), and then select the site which results in the rescue of most civilians in lesser time. This approach improves the performance of our rescue team to an extent. But it is extremely useful in a real life scenario where the disaster map is huge and the number of available agents is small. Grouping civilians will help in better decision making which is also computationally efficient.
2. Our agents prefer to explore an area around an already found civilian site or fire site. Since, by gaining early knowledge of a fire next to a group of civilians we can move ambulances and fire brigades quickly to that site and reduce the civilian loss.

Similarly, the knowledge of a large number of civilians close to a fire can help the ambulance agents in saving them.

3. We present some possible improvements in path planning and the communication model. We intend to implement and test these methods in the near future. We are also looking at a novel cost function based on the location of the fire-site and the number of civilian sites around the fire-site. Our cost function is biased towards saving more civilians rather than the buildings.

Rest of the paper is organized as follows: The exploration of our police agents is explained in section 2. The civilian rescue and our max-cut approach for finding civilian sites is explained in section 3. In section 4 we present our ideas related to path planning, communication model and fire brigades. We conclude our discussion in section 5. References are given in the last section.

2 Exploration

Knowledge of the positions of fires and civilians in the map is essential for agents to stop fires and rescue civilians. Exploration is mainly done by police agents and is supported by fire and ambulance agents. The police agents move through the unexplored areas and communicate the information of fires and civilians to the corresponding agents through the centers.

In the base code, each platoon of the same type of agents (i.e. ambulance, fire and police) explores the map independently. For each platoon, the map is divided into districts and each district is assigned to a single agent of the corresponding platoon. At each step the agent selects a target from its district such that the cost of travel is small and number of locations observable at that target location is large.

We improve the agent exploration by making use of the current information of the map. A priority is given to the unexplored regions according to the known importance of its surroundings. For example, exploring an unknown region with a couple of fires surrounding it is more important rather than exploring an unknown region with out any such threat. Similarly, searching for fires can be prioritized based on the civilian density in the vicinity. Target selection is based on the following equation:

$$L_t = \underset{l \epsilon L_D}{argmax} \;\; [(|O_l| + \beta_1 * f(l) + \beta_2 * c(l)) - \alpha * T(l)]$$

This function is calculated for all the locations l in the district L_D and the location with highest utility is selected. The value of this utility function is based on the number of other locations observable $|O_t|$ from l and the travel cost $T(l)$ of the agents to l. The constant α is found by experimentation. Function $f(l)$ is computed based on the location of the nearest fires and $c(l)$ is a value computed from the number of civilians around L_t. The constants β_1 and β_2 are obtained by experimentation.

3 Civilian Rescue

The rescue site has a number of civilians who are buried in the collapsed buildings. Civilians are the highest priority in the rescue environment. An ambulance agent is required to dig out a civilian from the debris. To maximize the number of civilians rescued, the ambulance agents should be utilized efficiently. In most of the previous teams including ResQ Freiburg, all the ambulance agents select a civilian with the highest probability of death and who would survive if rescued and rescue him together. This helps in faster rescue. After rescuing one civilian, the ambulance agents select the next civilian in a similar fashion.

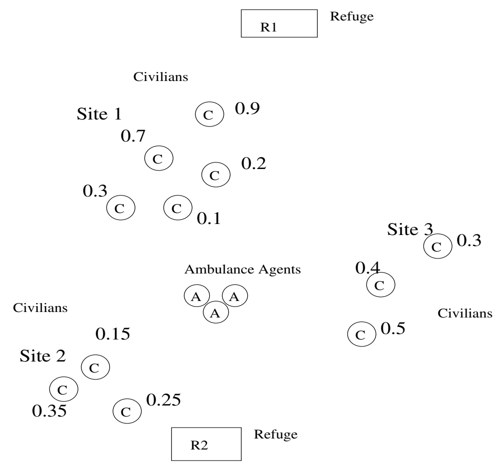

Fig. 1. A Civilian Rescue Site

A drawback in this approach is that, the cost of travel of the ambulance team from one civilian to another could be very large. For example, in a situation shown in Figure 1, the ambulance platoon moves from one site to another, using up a large number of cycles on travel. This is because at an instance the ambulance agents select a single civilian with lowest health who can be rescued in time. The path of the ambulances in this situation is as follows: Site1, R1, Site2, R2, Site1, R1, Site2, R2, Site3, R1 etc. This is definitely sub-optimal. Another major drawback of this approach is scalability. If the map size is too large as in a real-life situation, it imperative to divide the city into regions each being assigned to a set of ambulances. Since, the cost due to traveling to the far away regions of the map would exceed the benefits of the rescue operation. Similarly, if the size of ambulance platoon is very large, *one civilian at a time* approach will not be efficient. The contribution of a single ambulance agent in the rescue of the civilian can be lower than its travel cost. Dividing the platoon is essential in such a situation. Refer to subsection 3.1 for details.

Our agent team selects a civilian site which has a large number of civilians with low health and low travel cost and will rescue all of them one after another. We use a max-cut algorithm to group the civilians to form civilian sites. A graph is constructed with each civilian as a node and the edge cost between a pair of civilians is the spatial distance between them. Now, the max-cut algorithm divides the graph into two sub-graphs such that sum of edges between the nodes in the sub-graphs is maximum. Max-cut is applied on the sub-graphs recursively until the sub-graphs reach a minimum size. Max-cut was effectively used by [3] in a similar situation. Since max-cut is a NP-hard problem, we used the approximation algorithm from [4]. This approximate algorithm has an expected value of 0.87 times the optimal value.

Selection of a specific site is based on estimation of the number of civilians that can be rescued in the future. For example, a group of civilians right next to a fire should be rescued before another group far away from any fire site. The cost involved in saving a group of civilians includes the travel cost of ambulance team to the civilian site. The cost function for the civilian site selection is as follows:

$$G_t = {}^{argmax}_{G \epsilon S} [\gamma_1 * |C_d| + \gamma_2 * \sum_{c \epsilon C_d} (H_{max} - H_c) + \gamma_3 * f(G) - \gamma_4 * C(G)]$$

Where the target site G_t is selected based on the number of civilians who are close to death $|C_d|$ in that site, their combined health values (H_{max} and H_c are maximum possible health and health of a civilian close to death respectively), possible damage by nearby fires $f(G)$, and the cost of travel for the ambulance platoon $C(G)$. The values γ_1,γ_2,γ_3 and γ_4 are constants. The cost of travel is given as follows:

$$C(G) = |A| * d(A, G) + |G| * d(G, R)$$

Where $|A|$ and $|G|$ are the sizes of ambulance platoon and civilian group respectively. The function $d(A, G)$ denotes the distance between the ambulance platoon location and civilian location (civilian site). Similarly, $d(G, R)$ gives the distance between civilian location and closest refuge center.

3.1 Improvements for Large Maps and Large Ambulance Platoon

In this section we will first discuss the modifications required in the case of large maps and then discuss the strategy of the ambulance agents when the number of agents is large. The current method is to select a civilian and use the whole platoon (all the ambulance agents) for that civilian. This method will be sub-optimal if the size of the map or the platoon is large. The travel cost of the platoon in such a case might exceed the effort spent on rescuing that civilian. An optimal solution for this problem is NP-hard. So, here we present a greedy solution to this problem. For large scale maps, the whole region is divided into districts and each is assigned to a set of ambulance agents. This method is scalable in real-life rescue operations. In case of large platoon size, we group the civilians who are near to each other by applying a max-cut. Now we find the best group to rescue and assign a sub-set of the total ambulance agents such that the average travel cost for that sub-set is lesser than the average rescue effort. In the next step we select the next best group of civilians and assign the ambulance agents similarly. We repeat this process until all the agents are alloted.

4 Future Work

In this section we present some specific directions in which we would improve our agents. Our discussion is on the possible improvements to path planning, communication methodology and fire brigade agents.

4.1 Path Planning

The path planning corresponding to an fire brigade agent should depend on the exploration done around it, its water contents etc. Similarly, while traveling from a source to destination, choosing between two paths with nearly equal lengths, police agents need to select the path which is unexplored. If the water content of a fire brigade is almost nil and the agent has a choice of two paths, it should choose a longer path with water facility (refuge) instead of a smaller path without one.

4.2 Communication

Communication is the most important part of a multi-agent team. It is required to pass the information about the world and to co-ordinate actions among the agents. In the rescue environment the communication bandwidth is limited and should be used effectively. A platoon agent can send and receive up to 4 messages of 256 bytes of information in each cycle, while the center agents have a bandwidth equal to the number of agents under it. A possible improvement to the communication model is piggybacking the previous messages that were sent, i.e. we attach the most important parts of the previous messages to the current message, so that the reliability of the communication channel is enhanced.

4.3 Fire Brigade Agents

The task of a fire brigade agent contains two components: locating fires and extinguishing them. Exploration of the center of the map is more important since fire in the center can spread in more directions. Selection of the fire site depends on two factors, number of buildings that can be saved and the number of civilians that can be rescued. Damage due to a fire site in the future is also calculated. This cost function can be improved by incorporating the civilian site information instead of just the civilians in the surrounding buildings.

5 Conclusion

In this paper we presented our robocup rescue team Kshitij. Our major contributions are related to civilian rescue and exploration. Ambulance agents group the civilians into sites using a max-cut algorithm. Rescue of all the civilians at a single site will decrease the travel cost of the agents. Grouping also helps in faster decision making, by decreasing the search space. During the exploration, our agents prefer sites surrounded by fires or large number of civilians. These methods have helped in improving the performance of the agents, which is reflected in the scores obtained in the reference maps.

6 Acknowledgments

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References

1. *RoboCup Rescue League*. http://robot.cmpe.boun.edu.tr/rescue2004/, 2004.
2. A. Kleiner et. al. Resq freiburg: Team description and evaluation. In *Robocup Rescue Simulation Competition*, 2004.
3. M. Berhault et. al. Robot exploration with combinatorial auctions. In *International Conference on Intelligent Robots and Systems*, 2003.
4. M. X. Goemans et. al. Improved approximation algorithms for maximum cut and satisfiability problems using semidefinite programming. In *J. Assoc. Comput. Mach.*, 1995.
5. T. Morimoto. *How to Develop a RoboCupRescue Agent*. http://ne.cs.uec.ac.jp/ morimoto/rescue/manual, 2002.