MCD method for resource distribution in a large-scale disaster

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Abstract. Disaster rescue is one of the most serious social issues which involve very large numbers of heterogeneous rescue teams. In this paper, we introduce a co-ordination strategy for strengthening civil agents' lives in the RoboCup-Rescue simulator scenario based on Multiple-Criteria Decision Techniques. The co-ordination strategy allows distributing the ambulance teams (resources) to the victims that need the most urgent rescue (rescue tasks). Together with the co-ordination strategy a communication strategy has been deployed in order to assure that the decision making process has the appropriate information upon which to perform the resource distribution. The method described has been implemented in the Girona Eagles team.

1. Introduction

Disaster rescue is one of the most serious social issues which involve very large numbers of heterogeneous rescue teams. To provide new technology to give support in such hostile environments, it is unfeasible to realise the experimentation in real-life situations. Thus, computer simulations offer a valuable platform for testing any advance. One well known simulator is provided by Robocup-Rescue [1], to which our research is concerned.

In this paper we introduce the co-ordination strategy we have implemented for the Robocup Rescue simulator which tries to maximise the number of rescued civilians based on Multi-Criteria Decision (MCD) techniques. The co-ordination strategy highly depends on the information available regarding the rescue tasks. Therefore, communication of agents in the rescue domain is an important factor to affect the performance of rescue activities. Especially communication about civilians, who are the majority of agents in damaged area, is the primary information source for rescue activities [2]. Then, together with the co-ordination strategy, we also present in this work our communication strategy that allows the deployment of the co-ordination strategy.

This paper is organized as follows. Firstly, the rescue scenario is introduced in section 2. In sections 3 and 4, we describe our communication and co-ordination strategy. Finally, we provide some conclusions regarding the experiments performed.

2. Rescue Scenario

The rescue scenario provided by RoboCup-Rescue [1] is a disaster environment caused by an earthquake. In this scenario, there are collapsed buildings, fires, and blocked highways, people in a state of panic looking for safe places, and rescue agents helping victims. All agents have some general properties, namely id, hp, damage, position and buriedness. Id is the identification code of the agent. Hp measures the remaining life of the agents. Damage shows whether or not the agent has been hurt. Position indicates the location where the agent is in the rescue scenario. Finally, buriedness indicates whether the agent can move or is buried under a pile of objects. Other specific properties depend on the type of agent.

In the simulation environment, there are two types of agents: rescue agents and victims (civilians). The rescue agents are classified into moving and fixed agents. The moving rescue agents are the fire brigades, police and ambulances. The fixed agents are the agents that cannot move, such as the fire, police and ambulance stations. Every type of agent has certain communication and action capabilities, as shown in Table 1. It can be seen that ambulance teams are the only ones that are able to rescue civilians.

Type	Capabilities
Civilians	Sense, Hear, Move, Say
Ambulance team	Sense, Hear, Move, Say, Tell, Rescue, Load, Unload
Fire brigade	Sense, Hear, Move, Say, Tell, Extinguish
Police force	Sense, Hear, Move, Say, Tell, Clear
Central agents	Hear, Say, Tell

Table 1: Agents' capabilities

Rescue agents have to accomplish their objectives under strong communication and perception constraints in the surrounding area. Agents can only obtain vision and sensory information within a radius of 10 m in the large disaster area, with an area of 500 m^2. Furthermore, agents' communication with each other is highly limited.

3. The communication strategy

The communication strategy emphasises information flow concerning disaster victims. The role of the moving agents is to gather information about victims (position), and the role of the fixed agents is to pass on this information to the ambulance station. Moreover, ambulance teams keep the ambulance station informed about their condition: hp, damage, position, buriedness, availability and goal. The first four data have been already described in section 2. Availability means the current activity being carried out by the agent: "busy", if the ambulance team is trying to rescue a civilian; "free" if the ambulance team is looking for civilians; and "blocked" if the ambulance team cannot perform the task it has been assigned because of blocked roads. Finally, the goal descriptor indicates the current target of the ambulance team, i.e., the identification of the civilian that it is trying to rescuing.

The ambulance center then filter out all such information, that is, it is able to detect that two ambulance teams are busy on the rescue of the same victim as a consequence of a local decision upon contextual information. Then, only the closest ambulance team to the victim is allowed to continue with the rescue task.

4. The co-ordination strategy

Information about ambulance teams is considered as resources, while information on injured or buried civilians are the activities to be performed by the ambulance teams and which the ambulance station should co-ordinate. Which resource should be allocated to which activity is the decision that the ambulance station takes based on a MultiCriteria Decision-making (MCD) procedure. For our purposes, we need to apply the MCD method twice. First, to know the priority of the different activities to be performed, namely, the order in which civilian agents should be rescued. Second, to select the resource to be assigned to the most urgent activities.

- *Activity priorization.* At this stage, the different activities are the alternatives of the MCD method. The MCDM procedure is based on two main steps: First step, Rating of the different alternatives according to the different decision criteria and second, Rating of the different alternatives according to the importance of each decision criteria. We use the aggregation operator WA [3] for the rating of the alternatives. In the rescue problem, the decision criteria are damage, hp, buriedness and the number of victims at the same position. The corresponding importance is: hp 0,9, damage 0,7, buriedness 0,5 and Victims number in current position 0,6.
- *Resource distribution.* Now, the different alternatives are the resources available namely the ambulance teams. The criteria from which the MCD method performs the decision is based on the following features: hp, damage, and distance to the closest prioritized activity. The corresponding rating are hp 0,9, damage 0,7 and distance 0,6. The rating is applied in inverse order. That is, the alternative with minimum value is ranked first.

4.1 Example

To illustrate the MCDM process with an example, let us suppose that the current information about victims at the ambulance station is what is shown in the table below. In this table, is it possible to see the rating obtained for each alternative:

Alternatives (Victims Id)	Criteria			
	Hp	Damage	Buriedness	No. victims
2384	0,08	0,17	0,21	0,5
2388	0,21	0,21	0,5	0,5
2379	0,4	0,26	0,29	0,5
2338	0,1	0,11	0,13	1
2356	0,15	0,16	0,25	1
2367	0,24	0,22	0,13	0,5

According to the weigh assigned to each criteria, we get the following ranking by alternative: 2356 (0,974), 2379 (0,959), 2388 (0,886), 2338 (0,834), 2367 (0,731) and 2384 (0,614).

The ambulance central decides upon which ambulance team will perform the rescue activity. Suppose that the available information on ambulance teams is the following:

Id	Availability	hp	Damage	Distance
2399	free	0	0	0,1392
2400	free	0	0	0,1197
2402	Free	0,1	0.02	0,248

The ordered results (ranking) according to the resource distribution are the following: 2400 (0,07182), 2399 (0,08352), 2402 (0,2528). The resource distribution step will be applied as times as needed, in order to assign to each free resource a prioritized activity.

5. Conclusions

In this paper we have presented a coordination and communication strategy for the Robocup Rescue simulator. The co-ordination strategy has been designed based on a multiple-criteria decision-making technique with the aim of improving the number of victims rescued in a disaster scenario. In addition, the strategy implemented supports the communication process which is very important in the rescue scenario. Both, the co-ordination and the communication strategy have been implemented by the Girona Eagles team (http://eia.udg.es/arl/girona_eagles/). We performed three experiments:

- No coordination: that is, there was not communication at all between agents. Results showed that ambulance teams get lost in the rescue scenario and cannot find victims.
- Coordination between homogeneous agents: that is, communication between agents of the same kind (between ambulance teams and the ambulance station, between fire brigades and the fire station, and between police forces and the police station). Results improve and two civilians are rescued. One ambulance close to a group of victims is able to receive help from another ambulance and rescue civilian agents.
- Coordination between heterogeneous agents, according to the strategy presented on this paper. Results improve even more, since many more victim positions are known, and then can be rescued. Given the evaluation equation provided by Robocup Rescue Organization [1], our score is 38. The best score obtained in RoboCup Rescue 2002 is 90 by Arian; the second 87 by YowAI2002; the third one is 46 by NITRescue; and fourth is 34 by Kures2002; among 10 teams that participate in the 2002 tournament [1].

This study shows the importance of ambulance team coordination, although the remarkable impact of the heterogeneous agents' co-operation is also made clear by the simulation process results. We are currently exploring other alternatives on this line [4].

Acknowledgments

This work has been supported by the Spanish MCYT project DPI2000-0658.

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