Co-operation strategies for strengthening civil agents' lives in the RoboCup-Rescue simulator scenario

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Abstract-- **In this paper, we introduce two co-operation strategies for strengthening civil agents' lives in the RoboCup-Rescue simulator scenario: one for making communication efficient and the other for co-ordinating ambulance teams. For the latter, the co-ordination strategy, we use a Multiple Criteria Decision Making (MCDM) technique. This technique has been chosen due to the nature of the RoboCup-Rescue simulation environment, in which rescue decisions must be taken based on several alternatives with different constraints. In this dynamic and changeable environment, it is very important to have a good combination of all the possible variables found in order to reach the proposed goal - rescuing victims alive. The co-operation strategies have been implemented in the Girona Eagles team.**

***Index Terms*—Multi-Criteria Decision Making, Multi-Agent Systems, Rescue, Cooperation and coordination strategies.**

I. Introduction

In the general RoboCup project, Rescue is included with the aim of promoting research and development in the socially significant domain of rescuing victims from a disaster scenario. RoboCup Rescue involves multi-agent team work co-ordination and physical robotic agents in search and rescue [2,5,1]. One of the RoboCup Rescue scenarios is the simulation league where several heterogeneous rescue agents interact with one purpose: to mitigate an earthquake disaster. RoboCup Rescue simulator has objects and components which ake up a simulated world where paths, nodes, buildings, civilians and rescue agents can be found [6].

In this paper, we present a new approach to providing agents with a robust decision-making procedure in the rescue scenario based on Multiple Criteria Decision Making (MCDM) techniques that we have implemented in the Girona Eagles rescue team. Our aim is to develop a co-ordination strategy to help ambulance teams to rescue as many victims as possible. A combination of ambulance co-ordination and a good communication strategy has been proved to be vital in the Robocup Rescue competition [7,8].

This paper is organized as follows. Firstly, the rescue scenario is introduced in section 2. Then, in section 3 and 4, we present our communication and co-ordination strategies. Finally, we provide some conclusions and discussions regarding the experiments performed with the Girona Eagles team.

II. Rescue Scenario

The rescue scenario provided by RoboCup-Rescue [2] is a disaster environment caused by an earthquake, in which 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.

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.

TABLE I
AGENTS' CAPABILITIES

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

Furthermore, fire brigade agents have other properties such as water quantity, which shows how much water is in the tank, and stretched length which shows how long the hose has been pulled [6].

As in real situations, agents have a limited scope. Agent brigades can see visual information within a radius of 10 meters. Visual information is related to collapsed buildings, victims' locations and so on. Central agents cannot perceive visual information. Agents can exchange messages by voice (say and listen) and communication services (tell and hear). In the former, other agents located within a 10-meter radius perceive the message. In the latter case, the message is perceived by the same type of agents located in a 30-meter radius. Central agents can communicate with other central agents using communication devices.

In our work, significant effort has been applied to improving the performance of the ambulance team. A coordination strategy has been implemented, in which relevant information is stored at the ambulance station, and used to carry out an effective resource distribution (ambulance teams) using minimum communication resources (see next section).

III. The Girona Eagles communication strategy

The communication strategy of the Girona Eagles team 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. Figure 1 depicts the information flow.

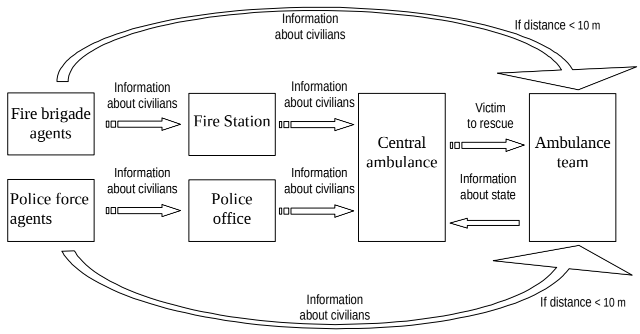

Fig. 1. Ambulance station communication flow

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 rescue.

IV. The Girona Eagles co-ordination strategy

The Girona Eagles co-ordination strategy emphasizes the role of the ambulance station in order to locate and then rescue as many victims as possible. The perception system of the ambulance station gathers the information sent by the ambulance teams and other moving agents that is stored as shown in Tables 2 and 3.

TABLE II.
INFORMATION SENT FROM AMBULANCE TEAM

Id	Availability	hp	Damage	Position	Buriedness	goal
2399	busy	10000	0	706	0	2345
2400	free	10000	0	901	0	
2401	busy	10000	0	690	0	2397
2402	free	9000	2	1850	0	
2403	busy	10000	0	76	0	2367

TABLE III.
INFORMATION ABOUT INJURED OR BURIED CIVILIANS

Id	Availability	Hp	Damage	Position	Buriedness
2384	9200	17	23	25	1
2388	7900	21	98	60	1
2379	6000	20	1129	35	1
2338	9000	11	2098	15	2
2356	8500	16	2098	30	2
2367	7570	22	1980	16	1

Information about ambulance teams (Table 2) is considered as resources, while information on injured or buried civilians (Table 3) are the activities to be performed by the ambulance teams and which the ambulance station should co-ordinate (see Figures 2 and 3). Which resource should be allocated to which activity is the decision that the ambulance station takes based on a multicriteria decision-making procedure.

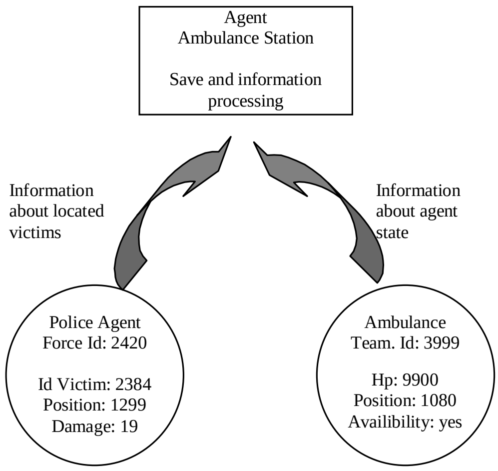

Fig. 2. Information sent to stations

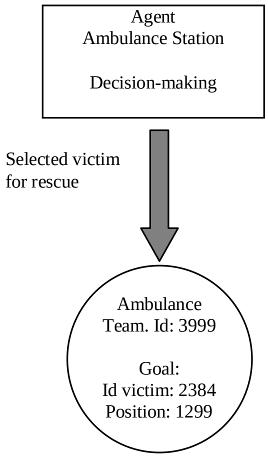

Fig. 3. Decision-making in the stations

The multiple-criteria decision-making (MCDM) technique allows which of the ambulance teams should perform the rescue of a given civilian to be determined, in a specific situation, taking into account the importance of each constraint involved (hp, buriedness, etc). The MCDM procedure is based on two main steps:

- *Rating of the different alternatives according to the different decision criteria*

Alternatives	**Criteria**			
	C_1	C_2	...	C_m
A_1	V_{11}	V_{21}	...	V_{m1}
A_2	V_{12}	V_{22}	...	V_{m2}
A_3	V_{13}	V_{23}	...	V_{m3}
:				
:				
A_n	V_{1n}	V_{2n}	...	V_{mn}

- *Ranking of the different alternatives according to the importance of each decision criteria. One possible way of rating the alternative is by using aggregation operators, such as the OWA [9].*

Alternative	Value * weight	Value * weight	Value * weight	Value * weight	Aggregation
R_1	$V_{11} * W_1$	$V_{21} * W_2$	...	$V_{m1} * W_m$	$\sum_{i=1}^{m} v_{i1} w_i$
R_2	$V_{12} * W_1$	$V_{22} * W_2$	...	$V_{m2} * W_m$	$\sum_{i=1}^{m} v_{i2} w_i$
:					
R_n	$V_{1n} * W_1$	$V_{2n} * W_2$	...	$V_{mn} * W_m$	$\sum_{i=1}^{m} v_{in} w_i$

In the rescue problem, alternatives are the various pending activities (rows of Table 3). Regarding criteria, we have used the following ones:

(C1): hp

(C2): damage

(C3): buriedness

(C4): number of victims in the same place.

The importance of the different criteria has been established as follows: C2> C1> C4> C3. The relative importance of each criterion is quantified in order to rank the different alternatives according to the following weights:

(C2): W2 = 0.9

(C1): W1 = 0.7

(C4): W4 = 0.6

(C3): W3 = 0.5

These weights are used at the rating stage of the MCDM procedure.

A. *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 Table 3. At the rating stage we thus obtain the following normalized values 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

And the ordered results (ranking) are the following:

Alternatives (Victims Id)	Value criteria * weight				Result
	Hp * weight	Damage * weight	Buriedness * weight	No. Victims * weight	
2356	0,15 * 0,7	0,16 * 0,9	0,25 * 0,5	1 * 0,6	0,974
2379	0,4 * 0,7	0,26 * 0,9	0,29 * 0,5	0,5 * 0,6	0,959
2388	0,21 * 0,7	0,21 * 0,9	0,5 * 0,5	0,5 * 0,6	0,886
2338	0,1 * 0,7	0,11 * 0,9	0,13 * 0,5	1 * 0,6	0,834
2367	0,24 * 0,7	0,22 * 0,9	0,13 * 0,5	0,5 * 0,6	0,731
2384	0,08 * 0,7	0,17 * 0,9	0,21 * 0,5	0,5 * 0,6	0,614

The table shows an ordered list of civilians to be rescued. The best ranked victim is the one whose identification number (id) is 2356, so this will be rescued first.

These results are then combined with the information on Table 2 (resources available). In this table there are two free agents (see availability column). As a result, the ambulance station sends a message to ambulance teams 2402 and 2400 in order to rescue the victims who are most in danger, 2356 and 2379 respectively.

V. Conclusions and discussion

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/). In order to test our strategies, we performed three experiments:

1. No communication: that is, there was no communication at all between agents. Results showed that ambulance teams get lost in the rescue scenario and cannot find victims that need to be rescued.
2. Communication 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.
3. Communication 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:

$$V=(P + S/Sint) * sqrt(B/Bint) \quad (1)$$

Where:

P: number of living agents,
S: remaing HP of all agents,
Sint: total HP of all agents at initial,
B: area of houses that are not burnt,
Bint: total area at initial.

The scores obtained in each experiment are: case1: V=29, in the case 2: V=34, in the case 3: V=38.

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.

For future work, we are thinking of deploying the co-ordination strategy used in the ambulance station to the other central agents (police office and fire station), taking communication constraints into account. We are also planning to include some learning mechanisms in the decision process of the ambulance station in order to adapt the decision procedure to the reliability of the information received from the various rescue agents as we have already done in other domains (see for example [10]).

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