The Proposal on Combination of RoboCupRescue Agent

Kuniyoshi Toda, Nobuhiro Ito

Department of Electrical and Computer Engineering,
Nagoya Institute of Technology
Gokiso-cho, Showa-ku, Nagoya 466-8555, JAPAN
agent-staff@phaser.elcom.nitech.ac.jp

Abstract. We propose a new game of RoboCupRescue Simulation League which encourages cooperation between agents from different teams. To provide real simulation, RoboCupRescue Simulation should be done as a large scale dispersed development. Accordingly the large scale distributed development of RoboCupRescue Simulation suggests the development of agents of RoboCupRescue Simulation League will also be large scale. In the traditional design method, researchers in the same group often discuss and agree their agents’ strategy among themselves before development. We propose to permit agents developed in isolation to participate in RoboCupRescue Simulation League. We also look at enhancing the scoring method which currently does not adequately evaluate cooperation between agents. We explore a new indicator which can measure cooperation using statistical methods.

1 Introduction

RoboCupRescue Simulation simulates a large earthquake and the disaster relief activities performed by many agents in a virtual city on network computers. The agents involved in disaster relief activities in this simulation are Fire Brigade (FB), Ambulance Team (AT) and Police Force (PF). FB extinguish fires, AT rescue buried civilians from buildings and PF clear blocked roads. Players from study groups in colleges or from business houses develop these three agent types to join RoboCupRescue Simulation League. In this paper we describe a group of players who join the league as a team, and collectively describe the agents (FB, AT, and PF) who join RoboCupRescue Simulation as an Agent Team.

RoboCupRescue Simulation needs more real simulation and we propose that one agent acts for one person. In the past, a researcher or study group has discussed the strategy of their Agent Team among themselves and decided how the simulation will proceed. However, it is difficult for one researcher or study group to develop such a large simulation system, so the system should allow large scale distributed development. In practice RoboCupRescue Simulation League will be developed both with and without discussion among the team members and so there will be a combination of independently-developed and group-developed
agents in the game. This will be cause problems in the future so we propose to combine agents in RoboCupRescue Simulation League.

The current scoring system of RoboCupRescue Simulation League cannot measure degrees of cooperation between agents. For this reason, we think that an indicator to measure the degrees of agent cooperation is necessary. We derive the cooperation indicator using Principal Component Analysis (PCA) and Factor Analysis (FA). We then propose a method for the indicator.

2 Proposal

To encourage flexibility and cooperation in an Agent Team, we propose to incorporate agents who are developed independently among other team members in RoboCupRescue Simulation League.

2.1 Background

RoboCupRescue Simulation needs more real simulation. A large scale distributed development is necessary for the realization, but this has not been considered in recent RoboCupRescue Simulation League. This is one reason why independently-developed agents behave unexpectedly, and to resolve this problem we propose a new approach in this paper.

2.2 Realization method of combination

We considered two methods of realizing the combining the agents:

- **Develop a protocol**: To let agents cooperate in the shortest possible time by preparing a framework for the realization of the cooperative behavior in advance

- **Develop interaction by considering other agents**: To let agents cooperate based on their autonomy and proactive behavior

We consider the autonomy and pro-activity of agents in this paper

- We consider a game which increases the autonomy and pro-activity of agents
- It is important to consider agents more because now we measure their social ability, autonomy and pro-activity.

Then, the following three points are promoted by proposing a game using this approach and by encouraging cooperation.

- Research about the design and implementation of agents that understands the intention of other agents
- Research about the combination of agents
- Research about an evaluation method of agents’ combination
The results of these investigations will enable the large scale distributed development. While we have selected the second method (develop interaction by considering other agents) in this paper, the former method (Develop a protocol) is not precluded, and should be considered in the future. For now, we consider that to develop a protocol for use with a large scale distributed development of RoboCupRescue Simulation would be unrealistic. Moreover, we have extended the RoboCupRescue Simulation server ver.0 to enable it to connect to more than one team.

2.3 Competition design

The game that we propose this time is the following.

- Let a participating team join an Agent Team with the same number as a fixed Agent. The participating team then competes for a degree of cooperation with the fixed Agent Team.

For example, if we set up a team of agents (six FBs, four ATs or five PFs) in Team (A) and a participating Team (B) joins with the same number as Team (A) agents then the teams are evaluated on the result of the interaction of these agents. (refer Fig.1).

We set up a team approach because we think that this is an easier way to vie for mastery. By keeping the three agent types separate, various cooperative behaviors will arise, such as a cooperation of a Team A’s FBs with Team B’s FBs and Team A’s ATs and Team B’s PFs and so on.

A variety of the other scenarios are suggested. Several examples follow.

- Compete for the degree of cooperation for fixed single-species agents (e.g. all the FBs of a team)
- Compete for the degree of cooperation for a fixed Agent Team (doesn’t fix the rate of the number of agents)
Let each of the participating 3 teams take charge of single-species agents, then see which group cooperates the best with the other teams.

Let the participating 2 teams join an Agent Team with the same number of members then see how well they cooperate.

Let the participating 2 teams join an Agent Team with a different number of members then see how well they cooperate.

These are the current suggestions for the game which we think are reasonable and are good examples for the new game. After more discussion about our study it is likely more scenarios may be adopted.

2.4 Evaluation of combination

The score is an evaluation standard of a recent RoboCupRescue Simulation League and is defined as below.

\[ P = \left( n_{al} + \frac{h_{al}}{h_{aa}} \right) \times \sqrt{\frac{S_{\text{NoBurned}}}{S_{\text{all}}}} \]  

\( n_{al} \): Number of the surviving agents
\( h_{al} \): Sum of the surviving agents’ HP
\( h_{aa} \): Sum of all agents’ HP
\( S_{\text{NoBurned}} \): Sum of the architectural areas of the flameless buildings
\( S_{\text{all}} \): Sum of the architectural areas of all buildings

When agents are combined as in our proposal, we don’t know which of the two teams the agents belong to.

- how well do they fit in, and
- how do they cooperate with each other.

We need to develop an indicator that measures how well an agent cooperates with another agent to replace the current score. And so we use Principal Component Analysis (PCA) and Factor Analysis (FA) to log data as an approach to derive the indicator.

We made a tool called Log Analyzer to collect the statistical data in a log then we output results from the calculations that might measure the cooperation (refer Table 1).

In the next section we first describe Principal Component Analysis (PCA) and Factor Analysis (FA). Then we discuss an analysis of the evaluation method used with the statistical methods.
Table 1. Items which might measure the cooperation

<table>
<thead>
<tr>
<th>Item</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extinguish rate</td>
<td>Number of extinguished buildings compared to buildings that ignited</td>
</tr>
<tr>
<td>Rescue rate</td>
<td>Rate of rescued agents to buried agents by a building collapse</td>
</tr>
<tr>
<td>Clear-off rate</td>
<td>Rate of cleared roads to blocked roads</td>
</tr>
<tr>
<td>Number of failed fire fighting attempt</td>
<td>The number of buildings where fires were extinguished more than once the number of buildings with fires that had not been extinguished at the end of the simulation</td>
</tr>
<tr>
<td>Number of failed rescues</td>
<td>The number of civilians rescued one or more times; the number of civilians who had not been rescued at the end of the simulation</td>
</tr>
<tr>
<td>Extinguish time for same target</td>
<td>Total time taken to extinguish the same building by more than two agents</td>
</tr>
<tr>
<td>Rescue time for same target</td>
<td>Total time taken to rescue the same civilian by more than two agents</td>
</tr>
<tr>
<td>Extinguish time for same target (success)</td>
<td>Total time to extinguish a fire in same building by more than two agents</td>
</tr>
<tr>
<td>Rescue time for same target (success)</td>
<td>Total time taken to rescue the same civilian by more than two agents</td>
</tr>
</tbody>
</table>

2.5 PCA and FA

PCA (Principal Component Analysis)

PCA is a method used to create a new synthesized indicator by integrating multivariate data. It creates a few synthesized variables by applying weights (Principal Component loading) to many variables. The way to weight the synthesized variables is to include as many characteristics of the original variables as possible. Then we create well-informed and synthesized variables (Principal Components) sequentially (refer Fig.2). The most well-informed PC (Principal Component) is said to be the 1st PC; the next most well-informed one is said the 2nd PC, and so on.

For example, when we look at the 1st PC which is the result of PCA for all items in Table 1, Extinguish rate and Number of failed extinguished buildings and Extinguish time for same target are weighted. The 1st PC may measure cooperation between FBs in this example.

FA (Factor Analysis)

FA is a method used to identify common factors behind multivariate data and is used to summarize data (refer Fig.3).

Whereas PCA is an analysis of the synthesis, FA is an analysis of the decomposition. The difference is shown in Table 2.

For example, when we look at the most well-informed Factor 1 which is the result of FA for all items in Table 1, it correlates strongly with Extinguish rate.
Fig. 2. Principal Component Analysis

Fig. 3. Factor Analysis

Table 2. Difference between PCA and FA

<table>
<thead>
<tr>
<th>PCA</th>
<th>Integrate data into PC</th>
<th>Deny error or analyze with error</th>
</tr>
</thead>
<tbody>
<tr>
<td>FA</td>
<td>Decompose data into implicit factor</td>
<td>Analyze error as unique factor</td>
</tr>
</tbody>
</table>
Number of failed extinguished buildings and Extinguish time for same target. Factor 1 may measure cooperation between FBs here.

3 Analysis of evaluation method

3.1 Extension of the RoboCupRescue Simulation server

Currently RoboCupRescue Simulation League is not designed for more than one team to join a simulation at a time. If more than one team connects their Agent Team to the simulator, the simulator cannot recognize it and the agent program sometimes aborts. We extend the RoboCupRescue Simulation server ver.0 and make it able to connect more than one team.

The following two methods to classify the Agent Team connecting to the simulator can be considered.

**Distinction by the connecting order** One team at a time connects. After every agent in the Agent Team is connected, the next Agent Team to connect is regarded as a new Agent Team.

**Distinction by the connected host** Use one client machine per one team. The simulator identifies the team by the connection host address.

We selected the former method for the server ver.0.47 and made it able to connect to more than one team.

3.2 Log Analyzer

In the current version of RoboCupRescue Simulation we only get a score value at the end of the simulation so we made a Log Analyzer which analyzes a log file of stored information and outputs various data as the values. At the present time we analyze only those items that might measure the cooperation as shown in Table 1, but we can gather other data and can explore these as needs arise.

3.3 Analytic procedure

After we define Cooperation between agents with the statistical methods for a log data, we explore a Cooperation indicator. The rough scheme is the following.

1. Choose 2 teams from 4 teams selected at random, then simulate all Combinations (using extended server)
2. Abstract the items which may measure the cooperation from a log file (using Log Analyzer)
3. Search the items which correlate strongly with the score
   (a) If there are some items which correlate strongly with the score in many log files we define these as the Cooperation between agents
   (b) Otherwise, perform PCA and FA for all items, then define the PC/factor which may express the cooperation as the Cooperation between agents
4. Experiment similarly for the other teams, then we consider if the definition is appropriate or not and explore if it could be the Cooperation indicator. At this moment, 4 teams selected at random are Phoenix / YowAI / Sample Agent(yabapi) / Caspian. We use a VC map (refer Fig.4) for all simulations, and configure the map to produce quake damage with middle difficulty. We simulated 50 times for all combinations.

Fig. 4. VC map

3.4 Result of analysis

In the analysis of this study we expected that some items, which correlate strongly with the score in many log files, to be identified as the Cooperation indicator. We also expected that some PCs or factors which correlate strongly with the score by PCA and FA, to be identified as the Cooperation indicator. Sometimes we could not find any item that correlated strongly with the score in many log files. So, we performed PCA and FA for all items (refer Table 3,4). Correlation with the score in the Tables is not the loading but the correlation factor between the score and the weight factor.

Looking at Table 3, in the 1st PC, the loadings for Rescue rate and Rescue time for same target and Rescue time for same target(success) are negatively large, while the loadings for Number of failed Extinguished buildings and Extinguish time for same target are positively large. So, the 1st PC may express cooperation between FB and AT, and it correlates inversely with the score. Therefore, if the value of this PC is small, the FB and AT may cooperate well.
Table 3. PCA result (Principal Component loading)

<table>
<thead>
<tr>
<th>Item</th>
<th>1st PC</th>
<th>2nd PC</th>
<th>3rd PC</th>
<th>4th PC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extinguish rate</td>
<td>-0.54</td>
<td>-0.25</td>
<td>0.37</td>
<td>0.61</td>
</tr>
<tr>
<td>Rescue rate</td>
<td>-0.89</td>
<td>0.13</td>
<td>0.28</td>
<td>-0.21</td>
</tr>
<tr>
<td>Clear-off rate</td>
<td>-0.40</td>
<td>-0.62</td>
<td>-0.42</td>
<td>0.20</td>
</tr>
<tr>
<td>Number of failed Extinguished buildings</td>
<td>0.73</td>
<td>0.42</td>
<td>0.22</td>
<td>-0.23</td>
</tr>
<tr>
<td>Number of failed rescue civilians</td>
<td>0.26</td>
<td>0.12</td>
<td>-0.88</td>
<td>0.098</td>
</tr>
<tr>
<td>Extinguish time for same target</td>
<td>0.65</td>
<td>-0.58</td>
<td>-0.015</td>
<td>-0.35</td>
</tr>
<tr>
<td>Rescue time for same target</td>
<td>-0.89</td>
<td>0.25</td>
<td>-0.20</td>
<td>-0.26</td>
</tr>
<tr>
<td>Extinguish time for same target (success)</td>
<td>-0.32</td>
<td>-0.77</td>
<td>0.099</td>
<td>-0.42</td>
</tr>
<tr>
<td>Rescue time for same target (success)</td>
<td>-0.88</td>
<td>0.29</td>
<td>-0.21</td>
<td>-0.25</td>
</tr>
<tr>
<td>Correlation with the score</td>
<td>-0.63</td>
<td>-0.40</td>
<td>0.31</td>
<td>0.27</td>
</tr>
</tbody>
</table>

Table 4. FA result (Factor loading)

<table>
<thead>
<tr>
<th>Item</th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extinguish rate</td>
<td>-0.24</td>
<td>0.32</td>
<td>-0.36</td>
</tr>
<tr>
<td>Rescue rate</td>
<td>-0.77</td>
<td>0.22</td>
<td>-0.58</td>
</tr>
<tr>
<td>Clear-off rate</td>
<td>-0.078</td>
<td>0.70</td>
<td>0.11</td>
</tr>
<tr>
<td>Number of failed Extinguished buildings</td>
<td>0.39</td>
<td>-0.77</td>
<td>0.081</td>
</tr>
<tr>
<td>Number of failed rescue civilians</td>
<td>0.017</td>
<td>0.0087</td>
<td>0.78</td>
</tr>
<tr>
<td>Extinguish time for same target</td>
<td>0.73</td>
<td>0.11</td>
<td>0.071</td>
</tr>
<tr>
<td>Rescue time for same target</td>
<td>-0.93</td>
<td>-0.26</td>
<td>-0.039</td>
</tr>
<tr>
<td>Extinguish time for same target (success)</td>
<td>0.089</td>
<td>0.63</td>
<td>-0.28</td>
</tr>
<tr>
<td>Rescue time for same target (success)</td>
<td>-0.92</td>
<td>0.22</td>
<td>-0.023</td>
</tr>
<tr>
<td>Correlation with the score</td>
<td>-0.30</td>
<td>0.54</td>
<td>-0.46</td>
</tr>
</tbody>
</table>
In a similar way, the 2nd PC may express cooperation between FB and PF. The 3rd PC may express cooperation between ATs because the loading only for Number of failed rescue civilians is large. The 4th PC might express cooperation between FBs, but Extinguish time for same target decreases with an increase Extinguish rate, so the 4th one may express the inefficiency of the fire-fighting strategy. Thus, the efficiency of the fire-fighting strategy is good if the value of this PC is small.

Using Table 4, in the Factor 1 the loadings for Rescue rate and Rescue time for same target and Rescue time for same target(success) are negatively large, and the loadings for Extinguish time for same target are positively large. Here, the Factor 1 may express a cooperation between FB and AT, but it doesn’t correlate with the score as well and it might express a cooperation which doesn’t surface in the score. Factor 2 may express cooperation between FB and PF, and Factor 3 may demonstrate cooperation between FBs.

We can check the propriety of these PC/factors using step 4 of the Analytic Procedure above then we investigate if these could be used as the Cooperation indicator in the future.

4 Future work

In the future, we will consider whether the indicators defined now are appropriate or not as an evaluation standard of the proposed game. We will also explore a way of deriving a better indicator which can measure the cooperation between agents more precisely. Finally, we want to explore a protocol to allow a communication between the combined agents.

Team Composition

Kuniyoshi Toda (Team leader) : 2nd-year master’s degree student at Graduate School of Engineering Nagoya Institute of Technology. Development and the design of the whole rescue agent.

Nobuhiro Ito (Team members) : Research associate of Graduate School of Engineering Nagoya Institute of Technology, Japan. Instruction and editorial supervision of the whole development, support, etc.