# FC Portugal 2004 Rescue Team Description: Adapting Simulated Soccer Coordination Methodologies to the Search and Rescue Domain

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**Abstract:** FC Portugal Rescue team is the result of a cooperation project between the Universities of Porto and Aveiro in Portugal. The project started in December of 2003 following previous collaborations of these two Portuguese Universities in RoboCup simulation league and associated competitions: Coach competition, simulation league presentation competition and simulation 3D competition. FC Portugal Rescue project intends to fully adapt the coordination methodologies developed by FC Portugal simulated soccer team to the search and rescue scenario. The first results of our team are very encouraging, making us believe that, after fully implementing our simulated soccer coordination methodologies in our rescue team, our results in RoboCup 2004 in Portugal may be quite rewarding.

## 1. Introduction

Search and rescue in disaster situations is a very serious social issue which involves a large number of heterogeneous agents working together as a team in difficult conditions in a very hostile environment. RoboCup Rescue international project intends to promote research and development in this socially significant domain at various levels involving multi-agent team work coordination, development of physical robotic agents for search and rescue, development of information infrastructures, personal digital assistants and standard rescue simulators and visualizators.

RoboCup Rescue Simulation Project is a now well established RoboCup [1] competition intended to promote research on this very serious social problem. The development of the RoboCup rescue simulator [2,3] offered a new practical domain for RoboCup and enables the application of research results achieved in RoboCup soccer competitions to a more sociably useful problem. Our team explores exactly this line of research, adapting successful coordination methodologies from RoboCup Soccer simulation league to the Rescue Simulation League.

The simulator (figure 1) is based on a generic urban disaster environment built using a network of computers. Several types of heterogeneous autonomous agents such as fire brigades, ambulances, police cars and civilians are faced with a search and rescue virtual scenario in which saving human lives and city infrastructures is the main objective in order to minimize disaster damage.

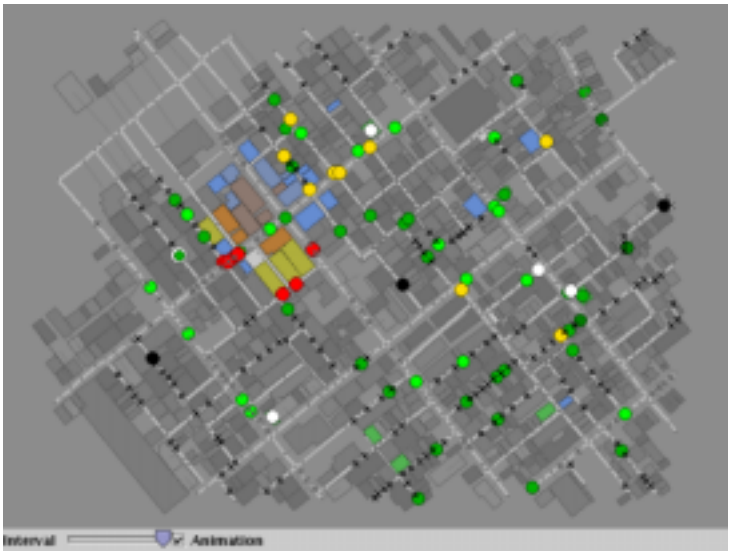

Fig.1: RoboCup Rescue Simulated Environment

For robotics and multi-agent researchers, RoboCup Rescue works as a standard platform that enables easy comparison of research results. The problem introduced by RoboCup Rescue brings up several research challenges that go from Intelligent Robotics to Multi-Agent Systems (MAS) research. These research challenges include real-time flexible planning, multi-agent coordination and team formation, low-bandwidth multi-agent communication, path planning and navigation, heterogeneous resource allocation and machine learning at the team level.

## 2. Team Development and Low-Level Decision

Since we are mainly interested in researching new coordination methodologies, in order to abstract from lower-level rescue simulation details we started our team by using the available YowAI 2003 source code [4].

The RoboCup Rescue domain [2,3] includes six types of agents that may be controlled by each team: Fire Brigade agents; Police Force agents; Ambulance agents; and Control centers of three types (fire stations, police offices and ambulance bases).

Center agents are responsible for message routing and global tactical reasoning for each type of agent. These agents are configured initially with the team strategy and try to follow it during the rescue operation.

Our agents' low-level strategy is mainly the following. At the begin of the search and rescue operation, Police agents try to free "main routes" in order to enable ambulance agents and fire brigade agents to move freely between far locations. "Main routes" are defined using previously established map strategic points and computing the distances of the free tracks to the strategic points. These points include not only fire spots and civilian refuges but also map strategic crossings. At the middle/end of the search operation (configured on the team

strategy), police forces are more concerned on freeing trapped agents and attending road clearance requests from other agents.

Ambulance strategy is fairly simple and is based on taking close civilian agents to refuges following known free paths. Close, severely injured (but not desperately injured) civilians are preferred for rescuing. A D* based algorithm is used in order to find the fastest free known paths for ambulance navigation in the map.

Fire combat strategy is more elaborated and is based on defining fire perimeters for known fires and on building neighbors. Fire brigades try to combat the fire using pre-defined collective plans for: attacking directly a fire, minimizing fire spread or containing the fire. For example, minimizing fire spreads is based on extinguishing fires in buildings that have a large number of neighbors and fire containing is based on minimizing the size of the fire perimeter. If fire is contained, fire brigades are used to search for buried civilians in order to maximize team global scoring.

## 3. High-Level Coordination Methodologies

After having our low-level code reasonably stable, our research is now focused on adapting coordination methodologies, developed for our RoboCup 2000 soccer simulation league team, to the rescue domain[1]. These coordination methodologies include:

- **Situation Based Strategic Positioning (SBSP).** This coordination mechanism [5,7,8] enables a team of agents to move in a coordinated way in a spatial domain, based on common a-priori tactical knowledge and simple environment knowledge [8].
- **Concept of Global Situation.** A situation is a high-level analysis of the search field that must be simple to perform by all agents, resulting in common global knowledge for all agents [8]. In soccer the situation is basically something like attack, defend, our goalie free kick, going from defense to attack, etc. In a search and rescue scenario it is something like avoiding fire spreading, attacking fire, etc. Although in the soccer simulated domain, the concept of situation is not of primordial importance for the SBSP positioning system, in other domains like battlefield or rescue, situations are very important for positioning agents.
- **Definition of a Team Strategy for a Competition.** FC Portugal flexibility lies essentially on our formalization of what is strategy for a competition [5,8]. This strategy is composed by tactics with activation rules (based on statistical information of the performance of the team in executing the task). Tactics include several high-level parameters like the group mentality, level of risk taken, etc. and also several formations to be used in different game situations (fire attack, sustaining fire in a line, etc.).
- **COACH UNILANG – A Standard Language to Coach a (Robo)Soccer Team.** Coach Unilang [6] was the first high-level coaching language introduced in RoboCup. It enables to improve team coordination by letting a supervisor agent to define the team strategy and perform the tactical changes in the team

[1] FC Portugal 2000, mainly due to its new coordination methodologies, was RoboCup European and World champion in 2000, scoring 180 goals in those competitions without conceding any goal.

during the execution of a cooperative task by a group of agents. In a search and rescue scenario, high level a-priori definition of the team strategy is essential to coordinate the team during the disaster. Coach Unilang with several high-level modifications will be used by our team to define the team strategy before the competition. This strategy will be followed by the center agents in order to coordinate the moving agents. Our coach for RoboCup Rescue is a simple application that performs off-line analysis of logfiles showing the team behavior, and decides the strategy for each rescue operation before the start of the competition.

- **ADVCOM – Intelligent Communication using a Communicated World State.** Intelligent communication mechanisms are crucial in RoboCup Soccer and Rescue due to the low-bandwidth available at these competitions. Our communication mechanism in the simulation league is based on agent's deciding the relevance of communicating a given piece of information by comparing their own world states with a world state constructed using only communication. Based on the differences between these two world states, agents decide which pieces of information to communicate [5,7].

Our research on team coordinating techniques is not limited to the RoboCup Soccer and Rescue domains and most of the methodologies developed for these domains are applicable to other domains in which spatial coordination is needed. These domains include battlefield scenarios, and RoboCup robotic leagues.

## 3. Conclusions and Future Research

Our team development is only in its beginning but the first results achieved are promising. Like in other RoboCup leagues, we believe that our high-level coordination methodologies may lead our team to achieve very good results in competitions, starting in our first participation in RoboCup Rescue[2]. Our Configurable Flexible Team Strategy and our Situation Based Strategic Positioning [5,7,8], now used by most of RoboCup Soccer Simulation teams seem to be a very promising coordination methodologies also for RoboCup Rescue. We plan to fully adapt, implement and correctly instantiate (for the search and rescue domain) these coordination methodologies in our FC Portugal team for RoboCup 2004 rescue competition, developing a very competitive team.

## References


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[2] FC Portugal Simulation League team won RoboCup World championship in Melbourne in 2000 in its first participation in RoboCup. FC Portus legged league team achieve 5th place in its first participation in 2003. FC Portugal Coach won RoboCup Coach Competition in 2002 in its first participation.

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