Robocup Rescue Simulation Competition: Status Report

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Abstract. This is the fifth anniversary of the Robocup Rescue Simulation Competitions and the tenth anniversary of the disaster that inspired the Competitions. This is a good time to take stock of what milestones have been achieved and what milestones we should be aiming for. Specifically, this paper looks at the goals that led to the establishment of the competition, the current status of the simulation platform and infrastructure, and finally suggests areas of the current simulation platform which should be improved and parts of the Robocup Rescue technical and social infrastructure which should be extended.

1 Introduction

2005 is the tenth anniversary of the devestating Hanshin-Awaji earthquake in Japan which killed more than 6000 people in Kobe city. The Robocup Rescue project was established in 2000 in response to this disaster in order to provide a system for facilitating research into disaster mitigation and search and rescue (SAR) problems [1]. The goal of Robocup Rescue is to ultimately help save lives and provide an important public good, especially in the light of recent natural disasters such as the Boxing Day tsunami, the 2004 Bam earthquake, and even minor disasters such as the recent flooding in parts of New Zealand.

This paper is organised as follows. Section 2 revisits the goals stated when the Robocup Rescue Simulation Competition was established. In Section 3, we review the progress made towards those goals in the last five years and whether the competition is moving in the right direction. We then consider extensions that could be considered in order to move the project towards achieving those goals. Section 4 discusses development of the simulator software. Section 5 considers ways to improve the collaborative research effort of the Robocup Rescue community and to link this research with real-world emergency services and related industries. Section 6 concludes.

2 Goals

The Robocup Rescue Simulation project was started with several goals in mind. The high-level objectives of the project are [1]:

A. Bredenfeld et al. (Eds.): RoboCup 2005, LNAI 4020, pp. 632–639, 2006.

1. To apply agent technologies to social problems in a way that contributes to human social welfare.
2. To provide a practical problem for development of novel research in multi-agent systems and artificial intelligence.
3. To promote international research collaboration via the Robocup competition.

The Robocup Rescue Simulation project "aims to be a comprehensive urban disaster simulator" [1] by modelling the state of roads, buildings and individuals in a city after a disaster. Ultimately, this simulator could be used for training, testing of emergency management plans and for real-time command and control in a real emergency situation.

These are ambitious goals so it is unreasonable to expect them to have been achieved in only five years, but we need to know how far we have come and where to go next.

3 Progress to Date

The Robocup Rescue Simulation project has successfully implemented an agent-based urban disaster simulator that allows researchers to experiment with different strategies for responding to the disaster. The software simulates an earthquake in an urban environment and handles building collapse, road blockage, traffic flow, fire and civilian behaviour, as well as the response of the emergency services [1]. Unfortunately, the granularity of the simulation is still rather coarse. Buildings are represented as polygons and classified as either wood, concrete or steel rather than having different types of buildings (such as office blocks, residential housing, hazardous buildings (e.g. petrol stations), factories, warehouses to name a few) with different features. Every fire brigade agent has exactly the same capabilities, rather than having some fire trucks with ladders, some with bigger water tanks and so on.

The scale of the simulation is also quite small at present. Maps are generally limited to less than 1000 buildings, and there are usually no more than 100 civilians and 50 emergency services agents. The communication model is simplistic and does not reflect important characteristics of real-life communications.

Some of these limitations are due to computer processing requirements - in order to add more civilians we need to be able to simulate their behaviour - which will become less of a problem over time as computer power increases. However, there are also some design limitations that need to be addressed. These are listed in Section 4.4.

Despite the small scale and low level of detail in the simulation a great deal of progress has been made in the last five years. The competition has been succesfully run every year since it began and the size of the community is growing steadily.

[1] Currently limited to fire, police and ambulance teams.

3.1 Simulation Platform

Development of the simulation platform has been fairly rapid, given the distributed nature of the community. The simulator kernel is fast and stable, and simulator modules for traffic flow, fire spread, building collapse, road blockages and civilian behaviour have all been implemented. Development is continuing in most of these areas.

In 2004 a new fire simulator was developed by the ResQ Freiburg team [2]. This simulator is a vast improvement over the old one and models the spread of fire much more accurately than before. It also increases the level of realism by allowing fire brigades to "pre-extinguish" buildings by pouring water on them to prevent a nearby fire spreading. In addition, buildings will re-ignite if left next to another fire for too long.

Development of a library of communication functions and other useful tools has started and will make maintenance of the system much easier in future.

3.2 Infrastructure

The most significant achievements have been in the community infrastructure. Organising and technical committees run each year's competition and steer the direction of development of the league, and a manual [1] has been written which describes the simulator and provides a guide for new developers.

In 2004 a secondary competition was added, the infrastructure competition, to promote development of new simulator implementations and development toolkits. This has already resulted in a new fire simulator developed by the ResQ Freiburg team [2] and 11 teams have pre-registered for the 2005 infrastructure competition.

An open source development model has been adopted for simulator development and all simulator code is controlled by CVS [3] on sourceforge.net [4]. The open source model allows for rapid development of interacting simulator components and also gives teams the ability to verify that simulator components perform as specified.

Finally, several development kits have been written that provide toolkits for developers that want to write agents for use in the Robocup Rescue Simulation competition. These include a C/C++ toolkit (the Agent Development Kit (ADK) [5]), and two java implementations: YabAPI [6] and Rescuecore [7].

4 Proposed Future Simulation Platform Developments

The simulator platform still requires a significant amount of development before it becomes a fast, fine grained, realistic simulation of an urban disaster environment. We have broken the simulator development into four modes: scale, detail, information and communication, and design.

4.1 Scale

Currently the simulator operates on a small scale, in the order of $1km^2$ of urban space composed of approximately 1000 buildings and a similar number of road

segments. The number of civilians and emergency services are limited to around 100 and 50 respectively. This obviously does not simulate reality very closely. The major difficulty with increasing the scale of the simulation is the increased computation time required to perform calculations.

The scale of the simulation needs to be increased in future, in terms of the size of the area simulated, the number of entities in the simulation, and in the time scales involved.

4.2 Detail

The level of detail in the simulation is also somewhat limited. Currently there are only three types of rescue agent - fire brigades, ambulance teams and police forces - and every instance of a type is identical to every other agent of the same type. In reality there are several types of fire truck, and agents have a diverse set of capabilities.

The representation of the world is at a low level of detail. For example, there is no way to specify that any building is more important than any other building. In real life it is clearly more important to save the hospital from fire than a single house. Similarly, there is no way to specify specific hazards such as petrol stations. Since, in real life, we would want to prevent a large fire from engulfing a petrol station it would be beneficial if this could be modelled in the simulation.

4.3 Information and Communication

The competition should attempt to move towards more realistic modelling of the knowledge that can be expected to be available to emergency service planners. Currently in the simulation, the emergency services have no *a priori* knowledge about the distribution of the population at the time of the disaster. In real life, there is *a priori* knowledge about how the population will be distributed at particular times. For example, the business district will likely be heavily populated on a Tuesday afternoon and almost deserted early on a Sunday morning. This sort of *a priori* knowledge would be useful for planning how to respond to disasters and would be available to real-life emergency service planners.

Similarly, the competition should attempt to move towards more realistic modelling of the communication environment. For example, in many large cities there are large microwave towers that handle much of the emergency services' communication channels. If those towers go out, much of the wireless communication disappears. Like hospitals, these towers would be important to save from fire, etc. If our simulation platform is to be useful for reasoning about how to respond to disasters, capturing these communicational dependencies would be important.

Finally, additional available sources of information need to be considered. Most modern cities have a large network of CCTV cameras for security or traffic monitoring, fire alarms and (in industrial buildings) hazardous material sensors and alarms. The addition of these and similar sources of information would increase the realism of the simulation.

4.4 Design

Compounding the limitations on scale, detail, information and communication are issues with the design of the software. The architecture has some limitations that make it difficult to add new features, and the quality of the code is quite poor in many cases. This is slowly improving as people in the community replace older modules with new ones, but there is a strong need for more quality control and better managed development. The adoption of an open source model using CVS [3] as a source control mechanism will hopefully improve matters in the future.

A full analysis of the existing software and a detailed code review would be highly beneficial as a large amount of code appears to be duplicated in each module and could easily be put into a seperate library. This process has started but is a long way from completion.

In the longer term, it would be useful to extend the software design in such a way that descriptions of the world could be made using a modelling language of some kind. Currently the abilities that agents have, the communication model and the organisational structure are hard-coded. It would be beneficial if it was possible to specify at runtime what kind of organisational structure to use, or to allow dynamic structures, for example to allow the formation and dissolution of teams during the course of the simulation. Similarly, being able to specify what equipment and/or capabilities each agent possesses would be useful.

5 Proposed Future Infrastructure Developments

5.1 Community Development

The Robocup Rescue community is somewhat fragmented at present. Although there are teams from all over the world competing there is little collaborative research or development. A project has been established on sourceforge.net that will hopefully encourage more participation in the development of simulator components, but a spirit of cooperation needs to be fostered within the community. The competitive nature of the simulation competition, while pushing researchers to produce better solutions, has the unfortunate side effect of encouraging teams to be secretive with their ideas and code.

Having a common "bulletin board" for the presentation of questions, ideas and contacts would make it easier for new researchers to become involved in the field and would also contribute to more of a "community feeling". Having a steering committee to guide the direction of development of the simulator and production of useful tools would also help to build the community.

Finally, the establishment of a program track or workshop at the annual Robocup symposium dedicated to Robocup Rescue would make it easier to consolidate the research that is being carried out at diverse institutions around the world.

5.2 Balancing Complexity and Accessibility

Improving the simulation so that it closely approximates reality raises an interesting dilemma: how can we balance the increasing complexity of the system with the need to keep it accessible enough for new researchers to become involved? A beginning team already has difficulties developing the most basic of agent implementations due to the complexity of the communication system and problem domain. The learning curve will only become steeper as the simulator becomes more realistic.

There is, therefore, a strong need to produce supporting code libraries at the same time as new simulator developments appear, as well as continuing the existing practice of asking teams to release their source code after every competition. The more tools that are available for teams, such as standard search algorithms, useful abstractions of the simulated world and communication libraries, the easier it will be for a new team to enter the competition. Of course, documentation will also be required if these tools are to be of any practical use.

5.3 Industry Development

Another area that needs development is the establishment of links with industry and government organisations. Clearly developing a detailed urban disaster simulation will be of little practical use if the real emergency services cannot apply it to their own activities. In addition, without input from the people who manage disaster risk professionally it is unlikely that the Robocup Rescue community will develop a simulator that is realistic. Discussions with the New Zealand Police [8] have already shown one popular misconception: after a disaster such as an earthquake, most people do not panic and attempt to flee the city. Instead, experience with real disasters has shown that survivors generally begin helping with the rescue effort almost immediately [9].

Development of industry links serves two main purposes:

1. Input from industry will ensure that the software developed accurately reflects what goes on in the real world.
2. Developing tools based on the simulator that industry can use will be beneficial to both the Robocup Rescue community and to real emergency services.

The ultimate goal of providing a system that can be used for training, testing plans and provision of real-time command and control support will never be realised unless the end users - the real emergency services - have an input from early on.

5.4 Development of a Roadmap

As we have seen several times in the last few years, disaster can strike almost anywhere and affect large numbers of people. Part of the appeal of the Robocup Rescue project is that it has the potential to help people. The best way to "contribute [to] human social welfare" [1] is for the competitions to help push the research towards something we can offer to emergency services.

The Robocup Rescue project could help in this respect by developing a roadmap of agent-based technology advances that might make contributions to emergency services. The roadmap could indicate milestones that would mark our field's progress towards points of advancement and would suggest how the competition might be expected to evolve. These milestones might be in the form of challenge problems.

The development of this roadmap should be a co-operative effort between researchers and emergency service managers. Ideally the emergency service managers would come from both national and international (e.g., the United Nations) agencies. One suggestion is that the Robocup Rescue Simulation Organising Committee look into the formation of a permanent Steering Committee whose members would be involved in organising the development of the roadmap and in monitoring the evolution of the competition according to that roadmap.

6 Conclusion

The Robocup Rescue Simulation League has come a long way since it was established 5 years ago. The software has been developed from scratch to include simulators for traffic flow, fire spread, building collapse, road blockage and civilian behaviour as well as the simulator kernel that binds these components together. Development is continuing on all aspects of the simulator platform, including new simulators and the development of libraries that will make development and maintenance of the simulator components much easier in future. There is still, however, a large amount of work to be done before the goal of providing a comprehensive urban disaster simulator can be achieved, most notably in increasing both the scale and the level of detail of the simulations. The introduction of the infrastructure competition in 2004 has encouraged development of high-quality simulator components and toolkit implementations.

The Robocup Rescue Simulation community is steadily growing in size. The main challenge at present is to provide a collaborative environment that makes it easier for researchers in different parts of the world to share information, find out what other researchers are doing, and to get help when they need it. The provision of a permanent website with "bulletin boards" and forums would go a long way towards meeting this challenge.

To help move the Robocup Rescue project effectively towards its goal of being able to help society better deal with large-scale disasters, we make the following suggestions:

- The Robocup Rescue Organising Committee set up a Steering Committee.
- The Robocup Rescue Steering Committee be responsible for developing a roadmap for how the competition should evolve in order to realise the Robocup Rescue goals.
- The roadmap should be developed as a joint effort between researchers and emergency service agencies.
- Ideally the emergency service agencies would include both national and international agencies.

- The roadmap milestones might be a series of challenge problems that would represent different points in the evolution of the competition.
- The Steering Committee would be responsible for monitoring the evolution of the competitions with respect to the roadmap.

In another five years, it would be good to report that the Robocup Rescue Simulation platform and the research arising from the competition had led to technology that enabled emergency service agencies to better cope with some classes of large-scale disasters. It would be nice to be able to say that lives had been saved because of our work!

References

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