A Rendezvous Based Coordination and Communication Model for Multi-agent System

Pooya Deldar Gohardani[1], Roohollah Mirsharifi[2]
Mechatronics Research Laboratory
Islamic Azad University of Qazvin
Qazvin, Iran
[1] pooya.deldar@qiau.ac.ir, [2] r@mirsharifi.ir

Mohammad Reza Meybodi
Computer Engineering and IT Department
Amirkabir University of Technology
Tehran, Iran
mmeybodi@aut.ac.ir

Abstract— **This paper proposes a rendezvous based approach to coordinate rescue intervention in an urban area where radio communication is not available. The approach use a method for partitioning the city in some regions and then pre-plan a meeting schedule for agents to exchange their knowledge about key information such as civilian's position and status. The approach has been implemented and evaluated on the RoboCup rescue simulator.**

Keywords-component; rendezvous, rescue simulation, multi-agent

I. INTRODUCTION

Earthquake is one of the most important disasters that humans facing in their life. After an earthquake the disaster management is the most important job to do. In order to research in this area a simulation environment for disaster management is made as a RoboCup league. Rescue simulation tries to simulate a city condition after an earthquake. Heterogeneous agents including police-force agent, ambulance agent and fire-brigade agent tries to help the city. The most important issue is coordination between agents. Coordination needs communication between agents but in communication limited environment like rescue simulation scenarios that radio communication is not available; it will be a vital problem.

In rescue simulation there are two kinds of communication: a long distance communication called "radio" and the second one is called "voice" is short distance. The main problem to coordination is when the radio communication is not available. In these scenarios the short distance communication is available. Limited information can be transmitted while agents are near each other's and that harden the information flow between agents.

Different solution for limited communication between agents is presented. It is while [10] tries to use human society cooperation model by legislation. The way to predict each agents behavior is the solution presented in [11] to coordination of agents in limited communication scenarios. Similar solutions are presented in [12, 13].

The paper presents a coordination method to overcome the limited communication between agents in multi-agent system based on rendezvous. Agents meet others in specific meeting points in specific period of time so they can communicate using their short distance voice communication and this will make an information flow.

A description about rescue simulation will be provided in section 2, in section 3 rendezvous method will be discussed and in section 4 the paper's approach to solve the mentioned problem and the result of simulation will be presented.

II. ROBOCUP RESCUE SIMULATION

Rescue simulation is a multi-agent system with heterogeneous agents in three groups, police-force agents, fire-brigade agents and ambulance agents. Ambulance agents are supposed to rescue injured civilian and move them to refuges. Fire-brigade agents have the duty to extinguish the fires usually exist after an earthquake. Police-force agents clear road blockades to let fire-brigade and ambulance agents move easily in the city and do their jobs.

A. Coordination

Similar to other multi-agent systems in order to have the best performance of agents to achieve their goal a good coordination method is needed. Every agent explores its neighborhoods and the information gained from environment should be shared among agents to let other agents make decision more precisely.

Several methods for coordination in multi-agent system have presented [2-6]. Sometimes coordination is presented as a task allocation problem [7, 8]. But they all work well as long as agents can communicate with each other's.

B. Communication

There are two kind of communication between agents in rescue simulation: radio and voice. By radio agents can send lots of information to other agents but by voice agents can send limited information in a short distance to their audiences.

The main problem is when the radio communication is disabled. This scenario is usually for an urban area. In this paper a rendezvous based communication model is

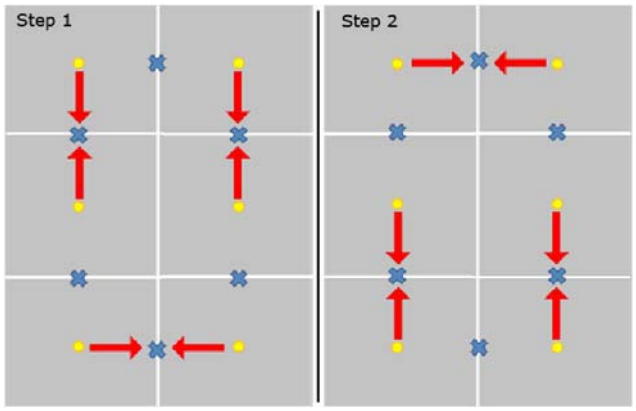

Figure 1. Two steps for simple rendezvous communication strategy for six-partitioned map

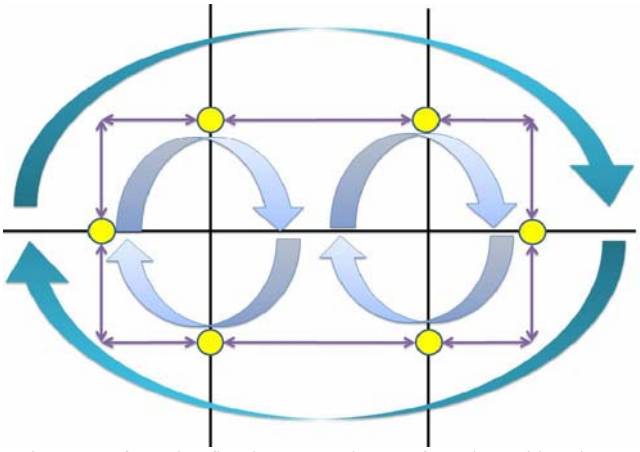
Figure 2. Information flow base on rendezvous for a six-partitioned map

presented to overcome this problem.

III. RENDEZVOUS PROBLEM

The rendezvous concept is presented as rendezvous search problem. The rendezvous search problem asks how two searcher units, randomly placed in a known search region, can minimize the time required to meet [1]. But in this paper rendezvous is a specific place that agents have set beforehand and they meet each other on that point in a specific period of time.

The problem is that agents can't share their knowledge about their local environment among other agents for example in an urban area which radio communication is not available. In order to manage this problem a short distance communication is used to make an ad-hoc connection while agents are at rendezvous. To do this the city is divided into some partitions. A point in the middle of two partitions is considered as a meeting point.

Different meeting strategy can be used for rendezvous approach. A two-step rendezvous is illustrated in Figure 1. In the first step they all go to one of meeting points. In the second step they move to the second meeting point of their partitions.

Figure 2 presents the information flow after some rendezvous steps.

IV. EXPERIMENTS

For investigating the rendezvous approach, an implementation is provided in the RoboCup rescue simulator. The goal is to increase the knowledge sharing ratio among agents so that heterogeneous agents can efficiently manage the rescue process. Police-force agents have the role of messengers on rendezvous points; meanwhile, they have the duty for searching and unblocking roads. Police-force agents are chosen for moving to rendezvous because of two reasons: police-force agents can clear blocked road on the way to rendezvous and also the police-force usually working in a partition so the sum of distance moved to rendezvous will be quite less that other agents which doesn't usually work on a fixed partition. Roads connected to meeting points might be blocked because of buildings' collapse; consequently, police agents are the best choice for rendezvous messenger's role. They can unblock roads while they are moving to reach meeting points.

A. Partitioning

The map is divided into partitions using a partitioning algorithm, according to police force agents' count and the number of buildings in the map. Particularly in the scenarios which has few police agents; accordingly, number of partitions will be the number of police force agents. Therefore scenarios without police force or with only one police force agent are not considered for rendezvous approach.

$$A=MIN(\alpha , B/\sigma) \quad (1)$$

$$N=MAX(A-(A \bmod 2) ,1) \quad (2)$$

Where α is the number of police force agents, B is number of buildings in map, σ is the number of building each agent can handle in a region (800 in the experiment), A is the number of partition needed and N is the number of partitions. (2) Make an even number of partitions for ease of partitioning.

As the number of buildings in the map grows in each scenario more regions are considered as partitions. But the number of partitions is limited to number of police force agents. Number of rows and columns in partitioning depends on the width and height of map's proportion, for instance as height of map grows compared to width, number of rows grows.

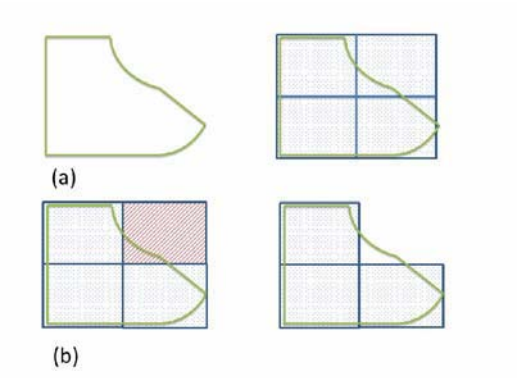

Figure 3. (a) Simple partitioning for a compound polygon map. (b) Pruning partitions with less that 20% overlap with map

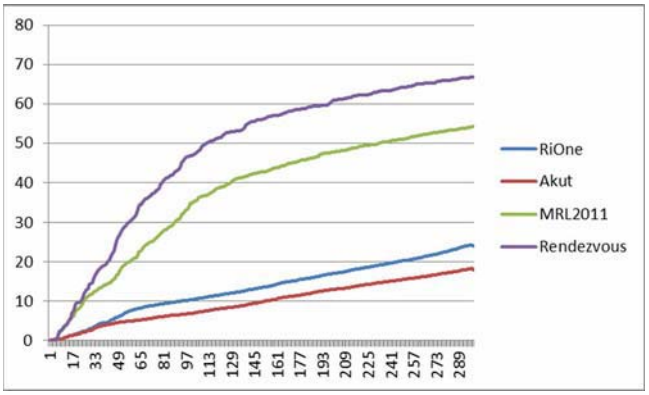

Figure 4. Average number of civilian, each agent knows in each simulation cycle for 10 different scenarios.

Figure 3 illustrate how a compound polygon map is partitioned. (a) shows how partitions are made at the first hand and (b) show how a partition is pruned. Partitions which have less than 20% overlap with the map are pruned. Agents who are not assigned for rendezvous will be in charge for the pruned place.

B. *Meetings points*

Nearest open road to the middle of each partitions axis are considered as meetings points. The points on the map axes are not considered as meeting points. For maps which has some pruned partition if a partition doesn't have a meeting point with any of other partitions then the vertex which has overlap with nearest partition is considered as meeting points. Number of meeting points for each partition, depend on number of axes each partitions has. Agents set meetings points on pre-computations based on map information given by simulator.

C. *Rendezvous*

Time to move to meeting points are set before hand and it is set based on map information such as number of partitions, average number of buildings in each partition and number of police force agents.

$$T = \beta/10 \times \rho/\alpha. \quad (2)$$

Where T is the Time period to move to meeting points, β is average number of buildings in each partition, ρ is the number of partitions and α is the number of police force. For instance a map with 10 police force and 200 buildings in partitions and 6 partitions the time period for moving to meeting points will be 12 simulation's cycles.

Agents simply move to meeting points every T cycle and they wait there for 2-3 cycles to see other agents and share information. Once information is shared, agents resume their ordinary duties.

D. *Information flow*

Other agents can receive information from two ways: Agents receive information from a police-force agents working nearby. Once they are in a 30m distance to a police-force short-distance communication will transmit information to them. The second way is to move to meeting points while they have lack of information. For instance, when an ambulance agent, have no more injured civilian position.

E. *Simulations*

The goal is to get higher information among agents once they are still doing their ordinary duties. Information about civilians is a vital data in rescue simulation. Once ambulance agent know about position and health status of a civilian, it is most likely to have the civilian rescued. Rendezvous is implemented on MRL-2011 agent code and compared with two successful teams from RoboCup 2010 competitions, RoboAkut [14] and RiOne [15]. The result for civilian information is illustrated in Figure 4. The figure presents number of civilians' positions each agent know. The result is made from 10 random scenarios which are simulated for 5 times for each agent code and the result presents the average info for each agent in all scenarios.

In Figure 5 other parameters such as score, saved civilians and moving time for search are presented. Although found-civilians exceedingly increased in rendezvous method but move to search parameter is not changed a lot from MRL2011. This shows that agents gain more information but they didn't search for it. Although ambulance method of rescue is a simple greedy algorithm, the result shows a little bit improvement in score in rendezvous method comparing to same agent code without rendezvous (MRL2011). Better ambulance algorithm while more information is available from the dynamic environment, will make a big change to the total score of simulation.

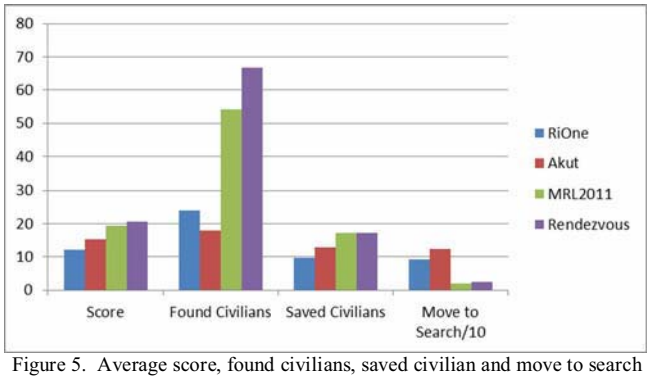

Figure 5. Average score, found civilians, saved civilian and move to search time, for 10 different scenarios.

V. SUMMARY

This paper presents a method that shares information among agents. The feature of the method is that agents are arranged to meet each other, exchange the information of assigned areas, and share the information of the all area.

Rendezvous method is implemented in RoboCup Rescue Simulation as a multi-agent system. A short description about Rescue Simulation related to the paper subject is presented and then rendezvous approach in an urban area which radio communication is not available, is presented. The result shows a performance increase in overall score while the information among agents is considerably increased. In summary this paper present a valid solution to the problem of decentralized communication in the disaster scenario simulated in the RoboCup Rescue league.

REFERENCES

[1] Alpern, S., Gal, S., "The theory of search Games and ., 2003Rendezvous", New York: Kluwer Publishers

[2] Ghijsen, M., Jansweijer, W., Wielinga, B., "Agent Decision Making for Dynamic Selection of Coordination Mechanisms", IEEE/WIC/ACM International Conference on Web Intelligence and Intelligent Agent Technology, WI-IAT, pp. 87-91, Sydney, 2008.

[3] Peng, J., Liu, M., Wu, M., Zhang, X., Lin, K.-C., "Multi-agent coordination method based on fuzzy Q-learning", 7th World Congress on Intelligent Control and Automation, WCICA, pp. 5411 – 5416, Chongqing, 25- 27 June 2008.

[4] Wu, J., Hong, Y., Shi, G., "Multi-agent coordination of networked mobile agents with hierarchical dynamic graph", 7th World Congress on Intelligent Control and Automation, WCICA, pp. 8239 – 8244, Chongqing, 08 August 2008.

[5] Guodong, S., Yiguang, H., "Multi-agent coordination with switching interaction structures and heterogeneous agents", 27th Chinese Control Conference, CCC, pp. 531- 535, Kunming, Yunnan, China, July 16–18, 2008.

[6] Sun, D., Wu, J., "Multi-agent Coordination Based on Contract Net Protocol", International Symposium on Intelligent Ubiquitous Computing and Education, pp. 353-357, Chengdu, 15-16 May 2009.

[7] Dias, M. B., Zlot, R., Kalra, N., Stentz, A., "Market-Based Multirobot Coordination:A Survey and Analysis", Proceedings of the IEEE , Vol.94, No.7, pp. 1257– 1270, July 2006.

[8] Kanaga, E., Darius, P., Valarmathi, M., "An efficient multi-agent patient scheduling using market based coordination mechanism", International Conference on Intelligent Agent & Multi-Agent Systems, pp. 1-4, Chennai, 22-24 July 2009.

[9] Tadokoro, S., Kitano, H., Tomoichi, Takahashi, Noda, I., Hitoshi, et al., "The RoboCup-Rescue: An International Cooperative Research Project of Robotics and AI for the Disaster Mitigation Problem", SPIE 14th Annual International Symposium on Aerospace/Defense Sensing, Simulation, and Controls (AeroSense), Conference on Unmanned Ground Vehicle Technology, 10 July 2000.

[10] Ajdari, M., Heidari, H., Tavakoli, A., Bavani, Amir M., "Cooperating Without Communication in Multi-Agents Systems by Emulating From Human Society", Proceedings of The 1st RoboCup IranOpen International Symposium, Qazvin, Iran, 2005.

[11] Aslanian, A., Markari, A., Falsafi, F., et. al: S.O.S. Team Description Paper Proceeding of Robocup 2010

[12] Genesereth, Michael R., Ginsberg, Matthew L., Rosenschein, Jeffrey S., "Cooperation Without Communication", The National Conference on Artificial Intelligence, pp. 51-57, Philadelphia, PA, August 1986.

[13] Bosse, T., Hoogendoorn, M., Jonker, Catholijn M., "The Distributed Weighing Problem A Lesson in Cooperation without Communication",

[14] Levent Akın, H., Yılmaz, O., Murat Sevim, M.: RoboAkut Team Description Paper, Proceeding of RoboCup 2010

[15] Matsuda Y., Ueno H., Komukai A., Yoshihara D., et. al: RiOne. Team Description Paper Proceeding of RoboCup 2010