MRL Team Description Paper for Virtual Robots RoboCup 2014, João Pessoa – Brazil

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Abstract. This paper describes the MRL team's works for participating in RoboCup 2014 Virtual Robots Competitions. This year our team has focused on fully autonomous robots, for achieving this purpose it is useful to have some abilities such as multi agent exploration, semantic mapping, map merging, and victim detection. In this paper we describe mentioned parts and also obstacle avoidance, path planning for semi-autonomous challenge and relationship tree between robots for manual challenge.

1 Introduction

In the virtual robot competition a disaster environment is simulated which could be explored with a team of rescue robots. It is based on USARSim, a high fidelity simulator based on the UDK game engine. Within USARSim users can simulate multiple agents whose capabilities closely mirror those of real robots. USARSim currently features wheeled, tracked and legged robots, as well as a wide range of sensors and actuators. Moreover, users can easily develop models of new robotic platforms, sensors and test environments. Validation experiments have shown close correlation between results obtained within USARSim and the corresponding real robots. Several research groups are using USARSim to develop control algorithms that are seamlessly migrated to field able systems.

MRL Team is participated in World RoboCup and Iran Open competitions from year 2006. The team consists of BSc and MSc students in different fields such as software engineering and artificial intelligence engineering. The experiences of this Team included of various aspects of AI, SLAM(Localization and Mapping), Navigation, Multi Agent Exploration, Image Processing, Ad-Hoc Network. Mechatronics Research Laboratory, MRL, works under supervision of Qazvin Azad University. Also in 2013 our team gains to first place in the Eindhoven World Competition [2]. In this paper we will concentrate on this year's innovations.

2 Team Members

Our team members and their contributions in team are:

Multi Agent Exploration	**:** Mohammad.H Shayesteh, Sara Hashemi
Semantic Mapping	**:** Atoosa Hashemi
Obstacle Avoidance	**:** Sara Hashemi
Map Mergin	**:** Mahdi Salamati
Path Planning	**:** Atoosa Hashemi
Victim Detection	**:** Adib Dehghan

3 Multi Agents Exploration

One of the fundamental topics in robotics is Multi Agent Exploration in unknown areas. Robots must search in unknown area and share their data to have an optimized exploration in the best time. This year, we are implemented three strategies named by Greedy Exploration, Knapsack Exploration and Centralized-based Exploration.

3.1 Greedy Exploration

This strategy is based on local search for each robot; they find some frontiers and rich the best frontier in unknown area. There is not any coordination between the robots. Also they are tried to keep their connections to base station for sending their sensed data.

DeHoog has shown that the Greedy algorithm is quite effective in exploring a large area in minimal time [10].

3.2 Knapsack Exploration

This exploration is appropriated for cutoff communion systems. In previous strategy, we were avoided the robots to searching out of wireless range, But in this system, we have knapsack memory on the robots, they can go out of the range and put explored maps and reached frontiers to Knapsack memory. Also they have a limited time to search in dangerous place. Each robot should come back to safe range after determined time. Then in that case we can search wider unknown area by the robots. This strategy is taken from Beyond Frontier Exploration [11].

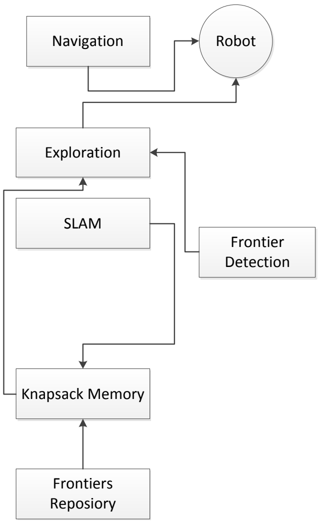

Fig.1. Knapsack exploration diagram

3.3 Centralize-based Exploration

In this strategy, robots are sent their detected frontiers to Base Station. These frontiers are gathered in shared graph tree in Base Station, after this we have a decision system on Base Station to select and assign the best frontier to robot navigations. Because it is possible that some frontiers are same between different robots or sometimes the selected frontiers will cause robots to move towards each other instead of being dispersed in environment. For solving these problems we make a list of all different frontiers of all robots. As a result, repetitious exploration is avoided by a shared and Centralize-based decision. In additional to, the semantic mapping results is using to prioritize frontier parameters, because the frontiers are in corridors help robots to explore more area than the frontiers are in rooms, therefore they get higher priority.

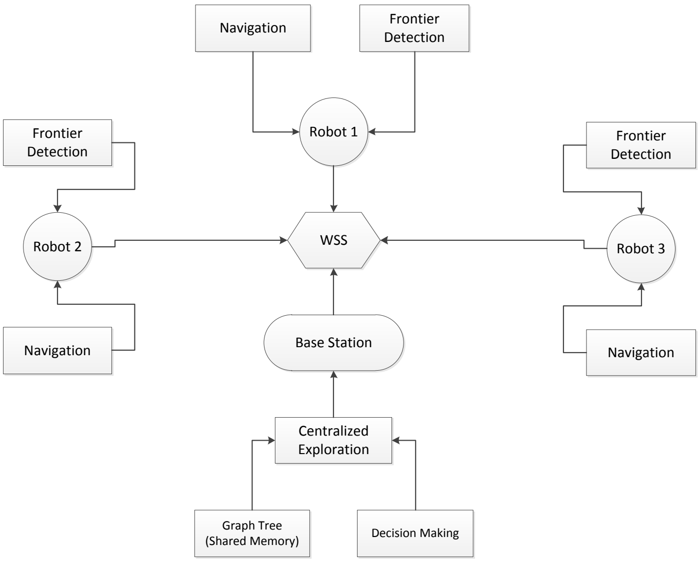

Fig.2. Centralized-based exploration diagram

4 Semantic Mapping

One of the key problems in multi-robot exploration is how to assign target locations to the individual robots for better distribute the robots over the environment [5][6] and to avoid redundant work, our multi-modal place classification approach is used to detect type of place (e.g., a corridor or a room or a door) and assign a special potential for every type of them. We use K-Means classification [12]. Three parameters of laser features that we use for semantic mapping are:

- Number of gaps: Two consecutive beams from a gap if the fraction between the first and the second is smaller than a threshold.
- Max beams / min beams
- Average and standard deviation of the length of the beams.

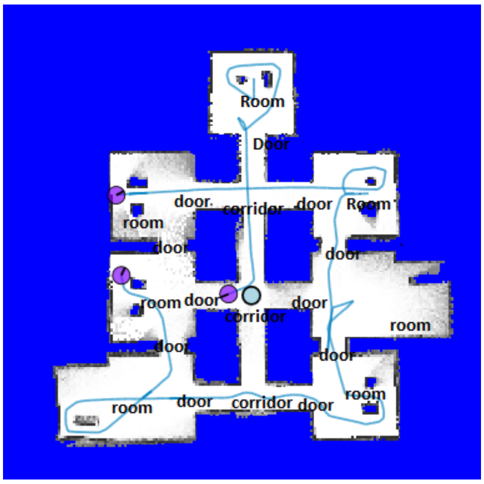

Fig.3. the figure shows typical observations obtained by robots at different places.

5 Obstacle Avoidance

We need an obstacle avoidance algorithm for autonomous robot because the path planning algorithm cannot have complete knowledge of the world and the shortest path can be very close to obstacles so that robot collides to obstacles on way (Fig.5.). We design an obstacle avoidance method as Modified VFH based following gap [7]. It has several advantages please give those comparisons, for example this method doesn't have the local minimum.

We use laser that its values specify distance of objects in front of robot. This algorithm calculates a threshold for gap width (gWidth) and a distance for detecting obstacles (obThreshold). Every object that its distance from robot is more than obThreshold isn't obstacle for robot. When the number of laser sequential beams that their values are more than obThreshold is more than gWidth, algorithm adds to gap list a new gap. Each gap is saved with an parameter that is distance from gap center to goal. This algorithm chooses nearest gap to goal because the robot doesn't miss the path to reach goal.

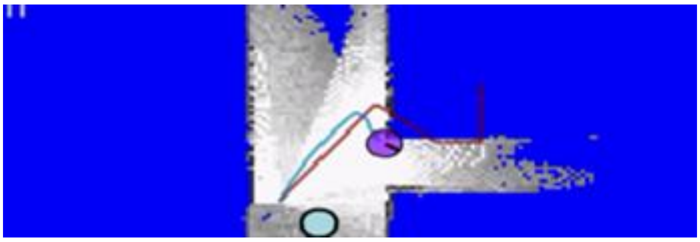

Fig.5. A, B and C are local maps.

6 Map Merging

Last year when the robot went out of the signal range of communications, it no longer could update the global map, Because its connection to ComStation(CS) was cut so robot had not any accessibility to global the map, in this year we design a separated module for each robot AI, duty of this module is explore and save the map in the Knapsack memory after robot disconnects from CS. At the end, each robot comes back to coverage area and CS merges all robots map and creates a global map.

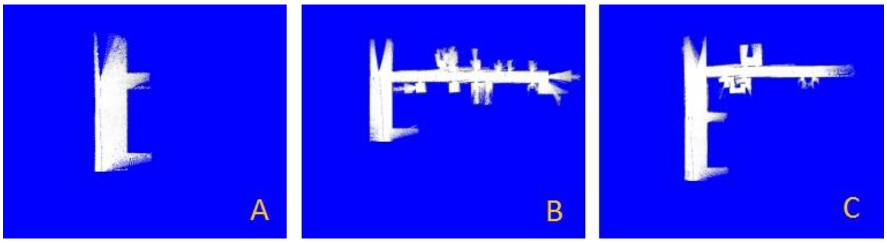

Fig.5. A, B and C are local maps.

7 Improved GUI

That was a difficulty that driver did not know the relationship between robots in routing algorithm. This year we have added routing algorithm visualization in our GUI to help driver for managing robots. Fig.6 illustrates Communication tree between robots.

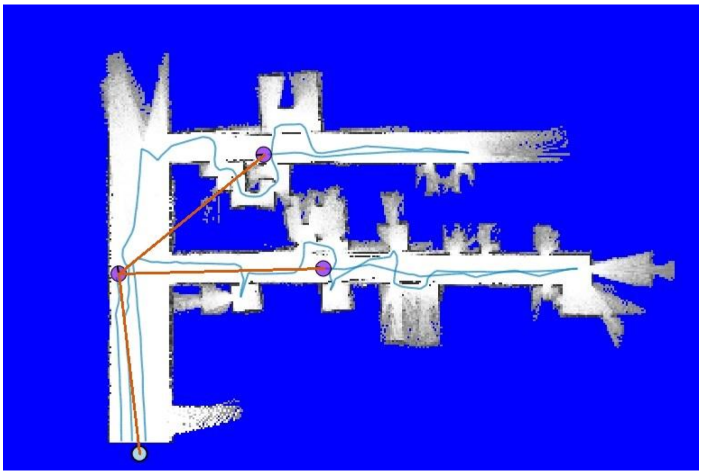

Fig.6. Communication tree visualization in GUI

8 Victim Detection

Previously we have a victim recognition approach that it was a HOG algorithm based Body Detection approach. This year we also implemented a fast human detection algorithm for using in online application. It was combined with refining foreground and using HOG feature.

Fig.7. victim detection

9 Conclusion

In this paper we describe the innovations in several modules which are needed for a fully autonomous robot. Future tasks of our team is adding a part to find out that a room included so many utensils or not by using image processing. This part helps us to make better decision in autonomous run and choose retired rooms, in crowded rooms robot may stick between chairs or something else that this information helps us to explore this rooms in last order.

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