RoboCup Rescue 2021 TDP
Agent Simulation
CSU_Yunlu (China)

Fu Jiang* , Ding Guo, Guanyu Cai, Wei Liu, Yiru Liu, Pei Xiao,
Haoyu Yang, Jie He and Longhao Yang

Central South University, China
Jiangfu0912@csu.edu.cn

Abstract. In this paper, we will describe the main methods and strategies of CSU_Yunlu in this year's RoboCup Rescue Agent Simulation. The buildings sre divided into different clusters by using k-means algorithm and optimized k-means++ algorithm. A* routing algorithm is used to enable the agents choose the optimal path. The partition-based communication method improves the efficiency of information sharing. The strategies for three agents (Police Force, Ambulance Team and Fire Brigade) improve the efficiency of the rescue operation.

1 Introduction

Team CSU_Yunlu [1] has been participating in the RoboCup rescue simulation competition since 2006. Moreover we have achieved good results in both RoboCup 2016, 2017, 2019 and 2020. We hope to optimize our strategy and improve the performance of our team based on the strategies we have in previous years.

Compared with last year, this year's project has changed a lot, including doctors can not rescue, firefighters can not extinguish the fire and so on.

The main contents of this article are listed as follows: clustering, path planning, communication and specific strategies for the three agents (Police Force, Ambulance Team and Fire Brigade).

2 Modules

2.1 Clustering

Purpose

In the rescue environment in RoboCup Rescue Agent Simulation, every map consists of thousands of nodes. In order to help the agents enhance the efficiency of searching the whole map, we need a clustering module to divide the wholemap into clusters. Each cluster can be seen as a smaller map, and the complexity of getting the information of each cluster is reduced greatly.It is convenient for each agent to be better allocated to each building set, so as to reduce the overlap between agents and improve the working efficiency.

* Corresponding author.

Related Works

Kmeans algorithm is a widely used clustering algorithm. This algorithm can not only classify a small amount of data. At the same time, it can be iterative and updated. And with the deepening of the iteration, it can be further optimized. However, if the data is large and the initial K center point is not set well, more energy will be consumed in the subsequent iterative optimization.

For the optimization of this problem, k-means++ algorithm can be used. By the way similar to the roulette probability[2], the initial K center points can be better determined. It can improve the optimization efficiency of the algorithm and reduce the running time.

Proposed Approach

K-means++ algorithm is used by our team to solve the problems of the clustering generation.
The specific algorithm steps are in the following approaches:

(1) A point is randomly selected as the first cluster center from the input data point set.

(2) For each point X in the dataset, calculate the distance D (x) between it and the nearest cluster center (which refers to the selected cluster center)

(3) Select a new data point as the new cluster center, the principle of selection is: the point with larger D (x) is more likely to be selected as the cluster center. Then, we will calculate the sum of D (x) of all unselected points, and randomly give a number in the range of 0 to sum, and then calculate the sum of D (x) from the first unselected node. When the sum is larger than our random number, this point is one of the center points we want.

(4) Repeat the steps of 2 and 3 until K cluster centers are selected.

(5) Using these k initial cluster centers to run standard k-means algorithms.

Pros and Cons

(1) It can better solve the problem of center selection in K clustering.

(2) For the case of large data or K value, D (X) calculation and subsequent iterative optimization will still take a lot of time. Because the initialization node is not fixed every time, and it can not be fully guaranteed that the initialization node is good enough every time the code runs.

2.2 Path Planning

Purpose

The pathfinding strategy is designed to help agents and citizens find the optimal path. The purpose is to make their movements more efficient and enable them to reach their destination faster. The efficiency of mobility is the most important foundation for rescue operations. Improving the efficiency of mobility means increasing the efficiency of all rescue operations.

Related Works

A* [3] is a widely used and efficient graph traversal and path search algorithm. By calculating the consumed value of the current path and the sum of the predicted value, the possible priority of each path can be

determined. In many cases, A* is the best solution. What’ s more, some other algorithms such as D* [4] and ARA [5] which based on A* can perform

even better than A* in certain situations.

MRL team [6] from Iran adopted the A* algorithm in 2019. With respect to the existence of the blockades, if the navigation doesn't work properly, it can cause a huge time waste. They implemented new graph based on area passable edges and available blockades. Their A* algorithm considers these passable and blocked nodes to finding shortest reachable route.

Proposed Approach

The main steps of the A* algorithm used by our team are as follows:

(1) Add the starting road to openlist.

(2) Take out the first node in openlist and add it to Closelist. Then, judge all the edges that can be passed. If they are not in openlist and Closelist, add them to openlist. Otherwise, compare and update the consumption value with the source node.

(3) According to F = G(current consumption value)+H(predicted value), all the nodes in openlist are sorted from small to large.

(4) When the openlist is not empty, continue to operate 2 and 3.

(5) Judge whether there is a path. If yes, the path will be obtained and output.

Pros and Cons

(1) A* algorithm is the fastest algorithm to calculate the shortest path so far. But in most cases, it is only a better algorithm, that is, it can only find the better solution, but often not the optimal solution. However, due to its high efficiency, it has a wide range of applications.

(2) However, the key of A* algorithm is how to select the evaluation function. The closer to the correct valuation function, the faster the correct solution can be obtained, but the completely correct valuation function is generally not available. As a result, the A* algorithm can not guarantee the correct solution every time. An unsatisfactory evaluation function may even make it inefficient, so that it will give the wrong answer. So we must choose different schemes according to the reality.

2.3 Communication

Purpose

Communication is an important factor for disaster relief. The information that an agent can obtain is limited. Sharing the information with other agents can improve the efficiency of rescue task. The key to communication lies in how to properly deal with the communication within partitions and the communication among partitions.

Related Works

For the communication method, there are not many descriptions in the previous Team Description Paper (TDP). In fact, there are many implementation methods at present. The difficulty lies in how to ensure the transmission efficiency while transmitting information to as many agents as possible. In some studies, information is identified by the importance levels. Then the agent chooses to filter part of the information for reception based on the importance levels, which improves the efficiency of delivery.

Proposed Approach

The communication strategy is generally divided into communication within partitions and communication among partitions.

Communication Within Partitions: Agent will judge whether the message is related to itself or not when receiving a message. If it is related, the agent will give priority to the task in this message. If it is not relevant, this message will be broadcast to the nearby agents. Other agents also reacted after making similar judgments.

Communication Among Partitions: Different agents have totally different tasks. However, the messages they catch from environment are helpful for all kinds of agents. For example, the Police Force agent may find buried humans. So They must immediately notice other kinds of agents once they get theses information to help save humans.

Pros and Cons

Advantages:

(1) Ensuring that the message is delivered in place.

(2) Ensuring that the message is spread rapidly.

Disadvantages:

(1) A large number of message senders will reduce the message processing efficiency.

3 Strategies

3.1 Police Force

Purpose

Police’s clean behavior plays an important role. In order to help the other agent to carry out the work in time and promote the efficient operation of the whole simulation system, we must ensure that the police agent behavior of high efficiency. Its efficiency is shown as the following three aspects: correctness, effectiveness, smooth.

Related Works

Team ZJU Base team [7] divides the police mission into three levels. The advanced tasks include self-rescue (avoiding harm to reduce damage), access to shelters (no obstacles around the shelter, ensuring that the agent can enter), and an urgent task is to help the stuck agent, intermediate and low-level tasks include various search tasks (search for fire points, roads and citizens, etc.)

Team SEU-Jolly [8] uses the grid division method to disperse the police in the early stage of police intelligence. At the same time, the distributed algorithm was used for task assignment and personnel scheduling.

Team MRL [9] used a guideline to help police force agents clear a road smother and prevent to create jagged blockades in a long straight path. What’s more, it will greatly improves the efficiency of road cleaning in early stage of rescue simulation.

Proposed Approach

Firstly, for task allocation, we divide task assignment into two categories: distributed task assignment in the absence of central agent and centralized task assignment based on central agent. According to these two categories, we propose a task assignment strategy based on task priority and

an another one based on the Hungarian algorithm.

Guideline Model

Determine the starting point of the bootstrap

(1) Obtain the road area where the agent is located, denoted as sourceArea.

(2) Get the connection boundary of the next region adjacent to the SourceArea and path, denoted as edgeTo. Get the middle of the boundary, call it middle.

(3) Make three straight lines: the connection line from the location of the agent to the boundary center point, the connection line from the location of the agent to the center of the road area where the agent is located, and the connection line from the road center to the boundary center, respectively denoted as agentEdgeLine, agentAreaLine and areaEdgeLine;

(4) Calculate the included Angle between agentAreaLine and areaEdgeLine, agentAreaLine and agentEdgeLine, respectively denoted as theta and alpha.

(5) Compare the size of θ and α, if $\alpha < 80$ and $\theta > 80$, the intelligent body position is the starting point of the guideline; Otherwise, the starting point is still the center of the road area where the agent is located.

The points, lines, angles and areas used in the above steps are shown in the figure below:

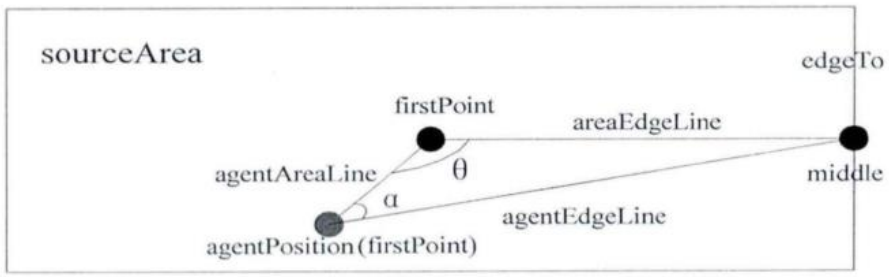

Fig. 1: The starting point of the path bootstrap

Plan the intermediate connection process of the path guideline

(1) traverse from the first road area to the penultimate area of the entire path.

(2) determine the starting point of the current region and the midpoint of the adjacent boundary between the current region and the next region.

(3) establish the regional guidance line from the starting point to the middle point of the boundary, and add it to the list of path guidance lines.

(4) take the middle point of the current boundary as the starting point of the next regional guideline.

(5) repeat steps 2 through 5.

A schematic diagram of the above process is shown below:

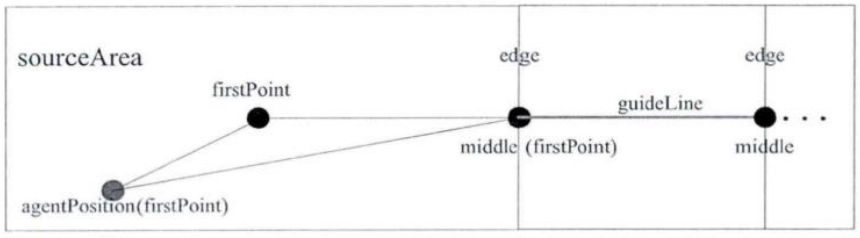

Fig. 2: The intermediate connection process of the path guideline

Determine the starting point of the bootstrap

All the intermediate and indirect processes of the path guidance line above start from the midpoints of two adjacent boundaries until the last area, that is, the road area where the target point is located.The path to be cleared by the police is planned to the target point, but not the area where the target point is located. At this point, the target point is used as the end point of the last area

guideline and the area guideline is added to the list of path guidelines. Schematic diagram is shown as follows:

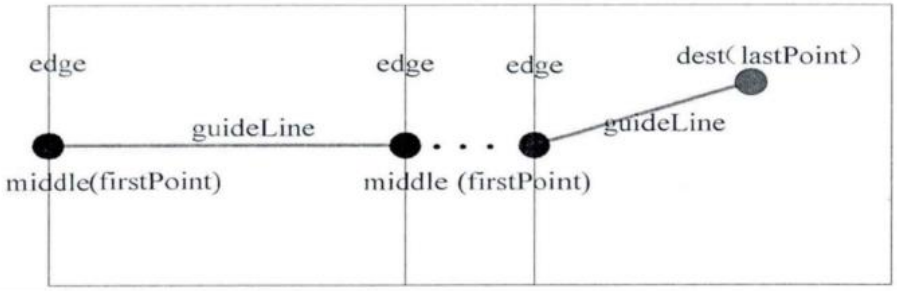

Fig. 3: Connect the Path Guidelines endpoint lastPoint

Experimental result

The figure below shows a comparison of the model with and without the guideline.

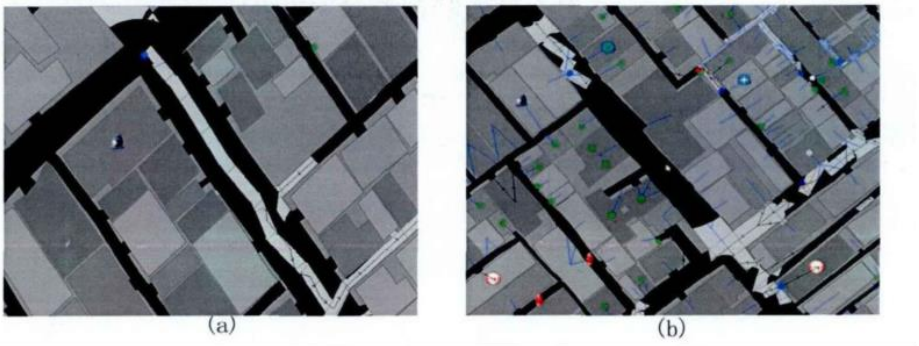

Fig. 4: Use the before and after guidelines

In figure (a), we used the guideline model. Obviously, compared with figure (b), figure (a) shows a smoother result of police obstruction clearance, with a significant decrease in the number of burrs and irregular patterns.

Pros and Cons

Advantages:

(1) The agent is adaptive to the dynamic rescue environment.
(2) The trajectory of the police agent can be optimized.
(3) The clear action save plenty of time result in the Convenience of other agents' rescue action.

Disadvantages:

(1) The quality of the communication mechanism seriously affects the results of task assignment.
(2) The Guideline model requires a more rational design when dealing with in- tersections and map edges.

3.2 Ambulance Team

Purpose

The task of the ambulance team is to rescue the injured residents from the fire brigade and deliver them to the appropriate shelter quickly and effectively. The task of the ambulance team has changed greatly compared

with last year. In order to adapt to the new version of the ambulance's function, we have changed the ambulance's strategy greatly.

Related Works

Compared with previous years, the work of ambulance team has been greatly modified, and it is unable to excavate and rescue the buried residents. Doctors will focus more on transporting injured residents to suitable shelters. The work of ambulance team is mainly divided into two parts. One of them is to quickly send the injured residents who are not buried to the shelter, and the other one is to assist the Fire Brigade to search for the buried residents when no injured person needs to be transported.

Proposed Approach

In order to make doctors treat as many patients as possible and find more victims, we optimized the doctor's decision-making and cooperation with peers:

(1) Classify the rescue objects,then set the priority and select the rescue objects according to the priority.

(2) After the target is established, the rationality of the target is judged according to the information obtained.

(3) Strengthen the cooperation ability of agents: through communication and cooperation, a doctor nearest to the injured residents will be selected to rescue.

(4) When no injured person is waiting for rescue, the doctor will search the building according to certain strategies, and inform the police to clear the road block if it is found. If the buried residents are found, inform the fire department for rescue.

(5) When doctors search for shelter after loading humans, they judge the time to arrive at the shelter and the sum of waiting time to ensure that the injured humans can get the fastest rescue when the shelter is occupied by a large number of agents.

(6) In calculating the rescue time, the correction time will be increased according to the calculation time. There must be a certain relationship between the correction time and the rough calculation time. For example, when the subject is next, the correction time is zero. By this method, it is possible to ensure that all subjects use the same treatment method.

Pros and Cons

Advantages:

(1) It uses weights to make decisions and ensure the rationality of decisions.

(2) The communication part of agent is optimized to enhance the ability of cooperation between agents.

Disadvantages:

(1) Strategies depends on the accuracy and timeliness of communication, and the ability of independent strategies is not strong. In specific cases, it will affect the rescue effect.

3.3 Fire Brigade

Purpose

In previous competitions, the firefighter agent's action is to extinguish the fire. But in the actual earthquake disaster, the fire rarely appears. So in the latest version, the map will no longer be on fire. And the duty of

firefighters also changed to rescue buried citizens.

Related Works

We follow the strategy of the past team doctors. The firefighters' behavior are divided into two parts, and one is to move to a known location of the injured citizens and rescue them. The other one is to search for an injured citizen. In the actual running scene, we observe that it takes a long time to rescue a citizen. By the end of the simulation, many people will die because they are not rescued. Therefore, we must ensure that most of the time in every firefighters is to rescue a citizen rather than to search for an injured one.

Proposed Approach

Rank the perceived injured citizens according to the distance, and then remove those who have died and those who can not be saved in the remaining time. Finally, choose the nearest citizen as the target. If firefighters don't feel the buried people, the firefighters will enter a building that hasn't been searched to find the people who need help.

Pros and Cons

Advantages:

(1) The efficiency of agent can be improved by choosing target according to distance first. At the same time, the priority of rescuing injured citizens rather than searching citizens can fully increase the number of injured citizens.

Disadvantages:

(1) There will be some firefighters to save a target and waste a lot of time to move to the target location.

4 Preliminary Results

We have compared us with last year's champion AIT on last year's final map.

Team / Map	sf	sakae	istanbul2	eindhoven	total
AIT-Rescue (ambulance can rescue)	90.73	119.65	227.54	123.55	561.47
CSU-YUNLU (ambulance can't rescue)	94.77	105.58	267.59	113.52	581.46

5 Conclusions

Different agents have different responsibilities and behaviors, so the priorities of tasks are different. Path Planning and Clustering are the most basic and important modules, so finding a better way to achieve them is a constant topic. We should design different strategies for different agents to achieve an efficient solution. At the same time, we can't ignore the cooperation between agents. Effective cooperation strategies can generate greater

benefits. Communication is the foundation of cooperation, so we try to use a reasonable communication strategy to improve the score.

In the coming period, we plan to absorb the advantages of other team agents, and then improve our strategies. Also, we will try to introduce more advanced methods and we will improve the behavior of some agents in the future, too.

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