UOWD - Tactical Rescue Unit Team Description Page

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Abstract. Tactical Rescue Unit aims to simulate human-like reasoning within our agents. A rule based system would make the agents flexible to work dynamically despite erratic changes in environment conditions. TRU has implemented a form of Mamdani fuzzy inference system within the agents. The main aim is to convert the application to become an educative tool in testing real life strategies.

1 Introduction

The Tactical Rescue Unit from University of Wollongong in Dubai (UoWD, TRU) team intends to participate at the RoboCup Rescue Simulation Competition, to be held in Portugal, in 2004. The main purpose of the team is to develop competitive Intelligent Agents whose mission is to rescue injured, buried civilians and extinguish fire sites in an optimum and efficient manner in a limited amount of time. The three different types of agents are equipped to function with different strategies that can be easily adjusted to any situation.

The base framework of the simulation is acquired from the 'Eternity Agents' provided by Mr. Ali Akhavan, a student hailing from University of Tehran, Iran. The agents' functional capability has been adapted to a new environment, namely an Expert System. The change allows more flexible decision-making and easy restructuring of the agent functioning.

2 The Plan

The Tactical Rescue Unit team aims at implementing a rule-based Expert System. The main goal is to build this idea into an education tool to facilitate training for rescue personnel. Some of the basic advantages of implementing a rule-based expert system are achieving simplicity, as rules help forming a psychological model for knowledge representation, as they closely relate to human reasoning. This reasoning helps us in creating a rule base, which define a near to real-life implemented rescue operation strategies.

Blocks of rules can be developed independently and added to a rule base. It is basically achieving modularity. A rule-based expert system can be broken down into manageable components for further development or modification, thereby incorporating flexibility into the system.

The Primary goal of the TRU team is to implement an Expert System to help the agents perform their tasks with less complexity and increased efficiency. The expert system is to help understand and carry out real-life rescue operation strategies before implementing them and also can be used to test efficiency of current strategies. The objective attained here is the results derived from the system, which can be studied and scrutinized for further improvement.

3 Decision making

TRU agents at the moment make decisions individually. The only form of coordination that occurs is from the consistency of the rules that give results to the agents based on various methods of evaluation and also due to the order by which each element is reported to these agents.

3.1 Police agents

Primary objective of the police agents is to reduce any form of interference in the rescue operations being carried out by Ambulance and Fire Brigade agents. They do this by clearing out the road blocks that come in the way of these agents. TRU agents so far have given priority to the work of Fire Brigade agents so far. The police agents move to a fire site and remove all blockades around that fire site, once cleared they move on to the next site for clearing. They also respond to calls for urgent clearance made by any other agent.

The police agents prioritize between different situations, giving most priority to urgent calls for clearance. They then concentrate on the neighborhood of the fires. Only after these blockades have been removed the agents consider other blockades. Once the disaster space is free of fires the police agents move onto a ‘search’ phase. Within this phase, primary objective of the agent is to track down buried civilians and report them to the center. This job is done by assigning regions to each agents and having them look through these regions allowing a complete sweep through the buildings.

3.2 Ambulance agents

Primary objective of the ambulance agents is to rescue civilians that are buried in the disasters space. The ambulance undertakes a search and rescue operation. It begins its search throughout the disaster space for civilians buried. Once a civilian has been found the agent concentrates on rescuing the civilian.

First priority goes to agents that are initialized as buried in the simulator. The next priority goes to civilians known to be in buried buildings. Evacuating these civilians is a sort of a sacrificial strategy. This is enacted only in certain dire situations. Implementation of this strategy is still being researched. However we would risk losing health points of the agents to rescue civilians so that in the long run we don't lose all the civilians to fires. All other civilians are considered after the above two special cases. TRU ambulance agents work separately and are usually restricted to two ambulances over the same civilian.

3.3 Fire Brigade agent

Fire Brigade agents are in charge of putting out fires that spread in the disaster space. TRU Fire brigade agents go through different phases while making decision.

The main phases that fire brigade agents go through are:
- Fire Site Choosing
- Building Choosing
- Putting of Chosen Building
- Searching for civilians

Fire Site Choosing. When choosing fire sites and buildings to put off, the agents consider the threat each fire poses to the disaster space. Based on some set guidelines the agents try to identify the threat of the fire and try to put off fires that are considered to be the most dangerous. Fire points spawn at various locations on the disaster space. It is up to the agents to decide which one to put off first. The TRU agents decide this considering three main factors:

Rate of Spread: Based on our observations, some of the factors that influence the rate at which a fire turns into a total burnout depend on the size of the fire site, the number of buildings around it and the sizes of these buildings. The agents consider all these properties of a fire site to determine the threat of this fire site.

Danger to Civilians: Civilians are given high priority by the fire brigade agents. An important factor to choosing a fire site is considering how much of a danger it is to civilians that are trapped in buildings. Any fire which comes in this category is considered as a high threat.

Ease of Putting Out: Some of the factors to consider in this are the number of buildings within the fire site, size of the fire, the distance from the refuge and the distance between the agent and the site. Based on this the agents try to consider fires that can be quickly put off to move on to the next site quickly.

TRU agents so far are committed to the site they select. They do not change fire site once they decide on a fire site. Once the site is chosen the fire brigade agents set about deciding which building to put off.

Building Site Choosing. Decision on the building to choose from is also considered similar to the fire site. When putting off fires within a fire site the agents are encouraged to work on buildings that form the boundary of the site. Like the decision on choosing a fire site, choosing a building is also based on a set of guidelines.

The main factors on which this depends are similar to the factors considered for choosing a fire site:

Rate of Spread: One way of measuring the threat of each building is considering how fast it will spread and how much this spread could damage. The main factors that are considered in this are the type of building, its fieriness level, its size and the number of buildings surrounding it.

Danger to Civilians: Again this threat is considered by checking the distance this building makes with the civilians in the disaster space. In this case the rate at which it may spread is also considered as part of the evaluation.

Ease of Putting Out: We consider the distance from the fire to the nearest refuge and also the distance to the agent. Agents can put off fires from within the refuge. This is ideal since the refuge cannot catch fire and the downtime to move to a refuge is zero, when the agent runs out of water.

Putting Off Building. The decision made on buildings however is more flexible. The agents change the building they work on depending on changes in the disaster space. If they consider that the change has made this building a lesser threat then they would decide to change to another building. They keep making 'pit-stops' to ensure that they have enough water to put off the fire. They also do a check to see if they have been damaged during the fire and return to the refuge to stop damage.

Searching for civilians. Once all fire sites have been put off they go into a search mode. Similar to that of the police force, the agents are assigned a region to search in and set about searching each building within their region for buried civilians.

3.4 Centers

The centers are currently being used as relay stations for messages to pass between agents of various types. TRU agents are currently in development to shift the decision making to the centers for some of the decisions. For example, the fire station would decide on the next fire site to choose, however decision regarding which building to go for would rest on the shoulders of the agents assigned to that fire. Within a fire it is possible to maintain a hierarchy of decision making by assigning ranks to each agent and having the agent with the highest rank have a better say in the decision making process.

4 Implementation

As mentioned above, we used an expert systems approach for our agents. The agents have a set of rules defining the decision making process. The focus since the last TDP has been on fire brigade agents. TRU has implemented a form of Mamdani Fuzzy Inference System into the fire brigade agents.

As mentioned above, sites and buildings are chosen by taking into account the various factors that affect the behavior of the fire in the disaster space. There are around 21 rules that evaluate the fire sites and 18 that evaluate the building the agent is to target next.

Examples of rules

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If (perimeter is medium) and (avgsize is small)
then (threat is high)

If (refuge is far) and (avgsize is big)
then (threat is low)
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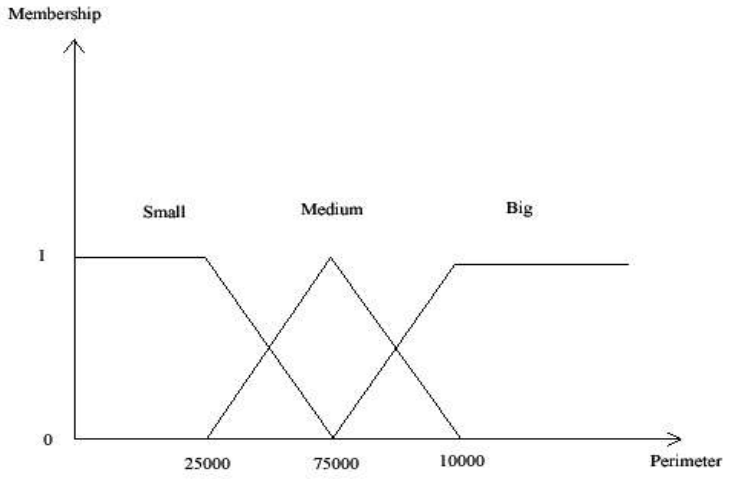
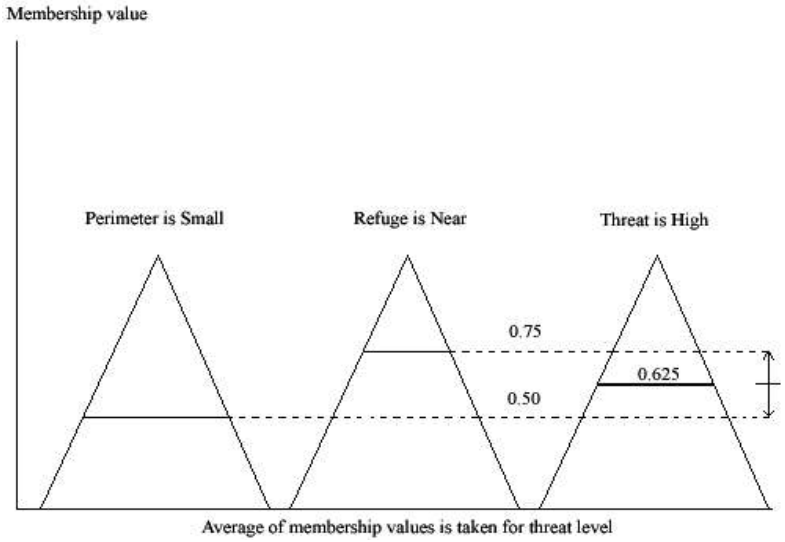
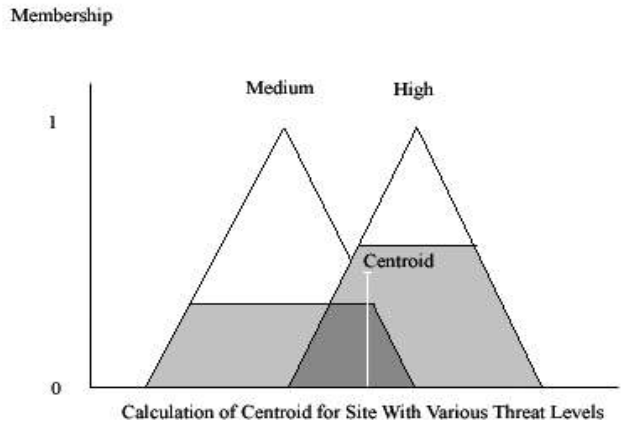
Every factor that is responsible for site choosing has a fuzzy set. An agent finds the appropriate member from the fuzzy set using the values of each of these factors. These factors are evaluated using a fuzzification function that returns one member from the fuzzy set belonging to that factor and a membership value denoting how much of a member this variable was to this element.



Each rule that decides on the threat level of a site or building relies on various factors. For every rule the average of each of the membership values of the factors in the rule fired is taken and this average is considered as the membership value of the threat.



A particular site may have many threat levels and membership values based on the rules fired. To crop this number down to a single threat level and membership value we calculate the centroid of the threat levels to get a singleton output.



We get a final threat value and crisp value for the site or building. Using the list of threat values for each building or site, we find the ones that belong to the set with the highest threat. Within this list we find the one building or site that has the highest crisp value. This would be the target for our agents to take to the next stage.

So far the TRU police and ambulance agents have limited decision making to implement such the expert system within the agents.

5 Agent Communication

There is a need for constant communication within the rescue unit to conduct an efficient rescue operation. Without communication each agent would be acting as an individual making it more difficult to pull off a successful rescue operation. In real life constant communication is one of the major requirements to achieve this goal.

The kernel permits two types of communication; AK_TELL and AK_SAY.

AK_TELL: This form of communication is used in communication between agents and their respective centers. It is considered as a broadcast message over mediums of telecommunication.

AK_SAY: This form of communication is limited in range and has a radius of 30 meters. It is a form of communication that allows agents to communicate amongst them. This is also used by civilians to denote their status when buried. This form of communication is considered as speaking by mouth or loudspeaker.

Communication is limited to 4 messages per agent. Centers are allowed only allowed messages amounting to twice the number of agents belonging to the center.

At the moment TRU agents only use AK_TELL to communicate. TRU agents currently report every significant disaster element in their vicinity to their respective centers. This includes buried civilians, blocked roads and buildings on fire. The information regarding the position and type of disaster element is sent to the center. The centers relay this information to the center that is responsible for the situation and from this center it is distributed to its agents. How these messages are dealt with depend on the decisions made by the agent. However agents do make sure they receive only the messages intended for them.

TRU agent communication is still under development due to the change in decision making hierarchy. This would see the agents relaying all required information to the center to make a proper decision and the centers sending commands to the agents to coordinate the efforts. In the previous communication model agents would relay all important information to the agents. Centers acting as relay stations negate the sole purpose of having a center.

A problem with this decision making hierarchy is that the centers don't have access to the disaster space as the agents have. This would limit their decision making since the center wouldn't be able to evaluate anything other than the reported elements. To enable proper decision making the communication would require agents sending in this extra information. This, however, could suffocate communication links since there is a lot of information to be sent. For this reason an efficient communication protocol is required to make this possible. This would vary for each agent however it is obvious this decision making is going to be tedious for fire brigade agents since site information would involve all properties of a site that are needed for decision making.

TRU agent communication is undergoing an addition to this communication system; the use of AK_SAY. Using the rank system this form of communication will allow agents to communicate when within audible distance to each other. This will allow agents to coordinate lower level decision making amongst them. Agents working elsewhere wouldn't have to deal with this message since they wouldn't be in audible range and wouldn't need to process this message making communication slightly more efficient.

6 Conclusion

We are still in early stages of the project and are progressing towards achieving the goals of the team defined in the beginning. The ultimate mission of this project to allow Intelligent Agents to efficiently act as a developed decision-support system. However, the current focus lies on converting the 'Robocup Rescue Agents' to implement a lightweight expert system shell. The future plan is to develop this into a training or simulation course for rescue personnel. The team's expectation is to develop an efficient and complete working simulation towards the beginning of June.