The Black Sheep Team Description

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1 Introduction

This short paper describes the functionality of the Robocup Rescue agents built by Team Black Sheep[1] at the University of Auckland[2]. We have implemented agents for each of the four components of the simulated environment: fire brigades, police forces, ambulance teams and emergency centers (fire stations, police offices and ambulance bases).

Our mobile agents are called Fireman Sam[1], PC Plod and Dr Ropata[2].

2 World model

Team Black Sheep agents maintain individual models of the world. The world is viewed as a collection of objects, such as buildings, roads and humanoids. Each object is a collection of properties, such as fieryness, width or damage. Each property has a timestamp associated with it - this is the last time that the agents knowledge of that property was updated. Updates can occur as a result of a KA_SENSE message arriving from the kernel, or they can come from communication with other agents (see section 3 for details).

When an agent attempts to update a property it must specify a timestamp showing when the new information was received. The old and new timestamps are then compared. The property is updated to the new value if and only if the new value has a timestamp greater than or equal to the old one.

For example, in timestep 10 a fire brigade agent sees a civilian trapped in a building. It will update that civilians buriedness and set the timestamp to 10. In timestep 20 it receives a message from an amubulance saying that the civilian was partially unburied in timestep 18. The fire brigade will again update the civilians buriedness, but it will use a timestamp of 18. If the fire brigade had seen the civilian again in timestep 19 and updated buriedness, then the update from the message in timestep 20 would fail, because the data was too old.

[1] http://www.cs.auckland.ac.nz/~rescue
[2] http://www.auckland.ac.nz

3 Knowledge Sharing

3.1 Messages

Messages are encoded using a set of message types and zero or more bytes of message-dependant data. Agents queue and prioritise messages internally during a timestep. When it comes time to send the messages they are packed into 80-byte chunks with highest priority messages in the earliest chunks. Up to four (the maximum number of messages allowed by the Robocup Rescue rules) of these chunks are then sent to the kernel. If there are more messages than can be sent, the remaining messages are stored for sending in a later timestep. Messages are all sent via the AK_TELL command, no use is made of AK_SAY.

3.2 Sending

There are 6 different kinds of message used by Team Black Sheep. These messages are detailed in table 1. The type of message is given as a single byte value (the *ID*). These values are also used as a means of prioritising messages - lower IDs are sent before higher ones. Each element of data is encoded in the minimal number of bytes necessary. For example, IDs are encoded as two-byte values. Although the kernel is capable of generating object IDs up to four bytes long this does not happen in practice. Two bytes, which can represent numbers up to 65536, are sufficient for now. This assumption approximately doubles the number of messages that can be packed into one 80-byte chunk.

Because the center agents can only receive $2n$ messages per timestep, where n is the number of platoon agents, the platoon agents send no more than two chunks per timestep. Similarly, the centers send no more than four chunks per timestep. Although the rate that messages are sent is less than allowed by the rules, this technique ensures that no messages are lost without being read.

Need rescue This message is sent by agents that are trapped in collapsed buildings. This is the highest priority message, as it is vital that all our agents are freed as soon as possible. The message contains the ID of the buried agent, it's buriedness and it's location, as well as a timestamp for the information.

Road request A request to clear roads is sent when an agent cannot plan a path to it's preferred target because of known blockages. Only the ID of the road is sent.

Road update Agents send updates of road status every time they receive a KA_SENSE message from the kernel. Every time the blockedness of a road changes the agents broadcast this information so that the whole team can update their world model. The ID, blockedness and timestamp of the update are sent.

Building update When a building changes fieryness all agents broadcast the change in much the same manner as the road updates. The ID, fieryness and timestamp of the update are sent.

Civilian update Similar to the road and building updates, a civilian update is sent whenever an agent notices a change in a civilian's properties. The ID, buriedness, location and a timestamp are sent.

Building searched When agents enter a building they send a building searched message to notify other agents that the building has been searched and does not need searching again. This improves the efficiency of the search for unfound civilians trapped in buildings. The building ID alone is sent. This message is the lowest priority.

Message type	ID	Data
Need rescue	1	ID of buried agent
		Buriedness of buried agent
		Location of buried agent
		Timestamp
Road request	2	ID of road
Road update	3	ID of road
		Blockedness of road
		Timestamp
Building update	4	ID of building
		Fieryness
		Timestamp
Civilian update	5	ID of civilian
		Buriedness of civilian
		Location of civilian
		Timestamp
Building searched	6	ID of building

Fig. 1. Messages used by Team Black Sheep

3.3 Receiving

Agents are only allowed to read a certain number of messages per timestep - four for platoon agents, $2n$ for centers. This is enforced by each agent. Platoon agents only listen to messages that come from the appropriate center and ignore all messages from fellow platoon agents. Centers listen to all messages.

Once an 80-byte chunk has been received the agent unpacks each component of the message and processes it. All agents respond to road, building and civilian updates by updating their world model. Centers will also forward the update if the new data resulted in a change to their world model. Centers will also automatically forward on requests for rescue, for roads to be unblocked, and building searched messages. Platoon agents do not forward messages on at all.

4 Path planning

Path planning for all agents is based on an A* algorithm using the Euclidean distance heuristic. Roads that are known to be blocked are considered impassable. If no paths to a target can be found, the shortest route with blocked roads is chosen and a request for the roads to be unblocked is made. The exception is PCPlod, who always chooses the shortest path to the goal and clears any blockages.

In addition to basic pathing, a simple traffic jam resolution scheme is included. If another agent is known to occupy a location on the path they are assumed to be creating a traffic jam. In this case, the location is considered impassable during path planning for this timestep. Each agent is assumed to occupy one lane, thus a two lane road will not be considered blocked unless there are two or more other agents on that road.

5 Agent Strategies

5.1 Dr Ropata

Dr Ropata is the implementation of the ambulance platoon agent. The primary duty of Dr Ropata is the rescuing of civilians. Civilians that cannot be rescued by the combined efforts of all ambulance agents before death or timestep 300 are not considered valid targets. From amongst all known, valid civilians Dr Ropata chooses the least buried civilian that he can reach.

If Dr Ropata knows of no valid civilians he enters a search state. In this state he enters the closest unburnt, unsearched building in an attempt to discover new buried civilians. After a building has been entered by any Dr Ropata agent it is considered searched and no further agents will enter it.

In addition to this behaviour, Dr Ropata will attempt to rescue trapped platoon agents if any are known. These are higher priority than trapped civilians.

5.2 PC Plod

PC Plod is the implementation of the police platoon agent. PC Plod maintains a list of all requests for blocked roads. The nearest request for clearing a blockage is always chosen first. If the blockage cannot be reached (in the event of a traffic jam) then the next nearest blockage is considered, and so on. If no requests can be reached, or no requests exists, PC Plod chooses the nearest known blockage. In the event that there exist no known blockages he takes a random walk through the roads of the city. This should assist in the discovery of new blockages and preventing this agent participating in traffic jams.

In addition to the standard PC Plod, two police agents were reserved for knowledge gathering. These agents choose a random fire and plan the shortest path. Any blockages on this path are removed. Once the fire is reached, another random fire is chosen and the process repeats. This procedure provides two useful services. The first is that it creates a path between fires that is free of blockages. This increases the likelihood of Fireman Sam being able to plan paths that do not require requests for road clearing. Also, this gathers information about fires at which no other agents are present. This is especially useful for Fireman Sam who must keep track of the extent of all fires in the city. In particular it prevents the fireman underestimating the severity of distant fires. If no fires exist, this agent wanders randomly as for the standard PC Plod.

5.3 Fireman Sam

Fireman Sam is a most divinely inspired implementation of the fireman agent. The most important function of Fireman Sam is the selection of a burning building for extinguishing. As the agents do not explicitly coordinate their activities, the building selection is required to be deterministic. Before describing the building selection scheme, the concept of a *perimeter* must be defined.

A perimeter is a set of burning buildings, each of which is adjacent to one or more unburnt buildings. A burning building is considered adjacent to an unburnt building if it is within ten meters per fieryness. For example, a building with fieryness two is considered adjacent to all unburnt buildings within 20 meters. If we consider a graph where nodes are burning buildings adjacent to unburnt buildings and edges exist between nodes if the two buildings are adjacent, then a perimeter is a single connected component of this graph.

The building selection begins with selection of a perimeter. This is always the easiest to extinguish perimeter that can be reached. Ease of extinguishing is a function based primarily on total floor area of the perimeter. Once a perimeter is selected, the building that is adjacent to the highest number of extinguished buildings is chosen. This causes the firemen to progressively extend the row of extinguished buildings, rather than buildings scattered across the perimeter. The lines of extinguished buildings generated by this approach are much more resistant to being enveloped by fires than individual extinguished buildings. If two or more buildings have an equal number of extinguished neighbours, the easiest to extinguish is chosen first. In this case ease of extinguishing depends on building type and total floor area. As a perimeter is extinguished its ease of extinguishing is reduced - either by splitting it into two smaller permimeters or into a perimeter with one less building. Thus, as a consequence of the perimeter selection and ease of extinguishing function, the firemen tend to work on a single perimeter until it is is completely extinguished. An example of how the perimeters can change due to buildings being extinguished (or burning out) can be seen in figure 2.

6 Summary

We have broadly described how the Team Black Sheep agents have been implemented. Each platoon agent selects targets from a priority queue and attempts to plan paths that avoid blockages and traffic jams. The police agents will prefer

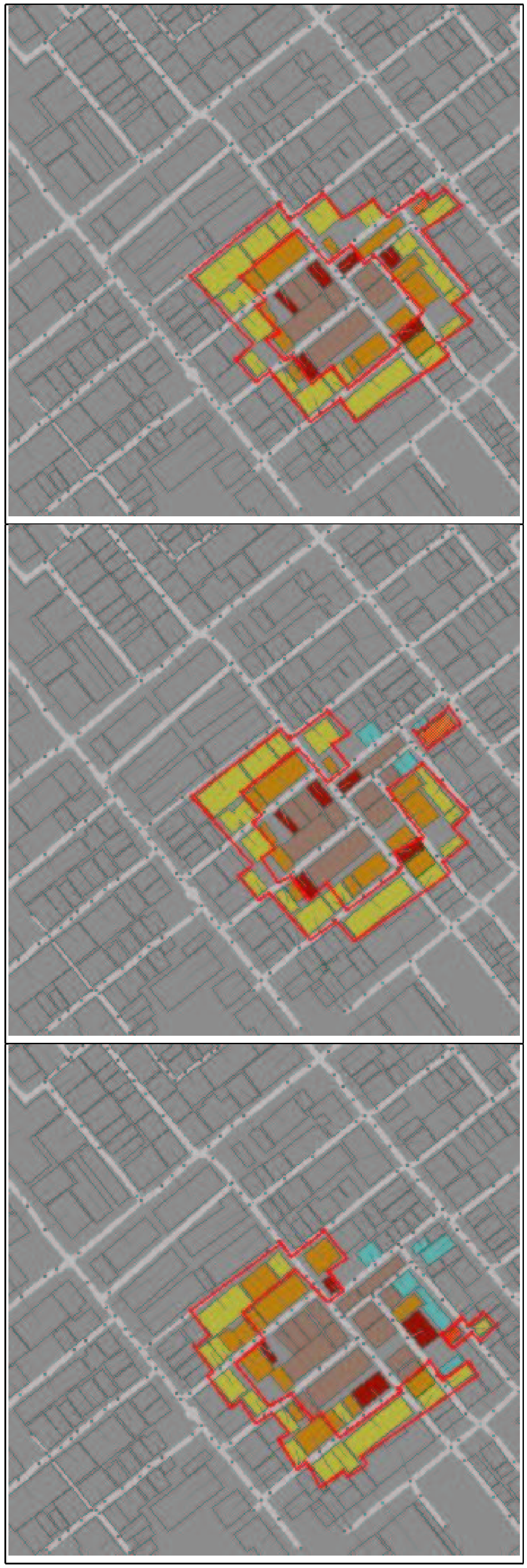

Fig. 2. Example of changing perimeters

to respond to requests to clear roads, the ambulance teams will dig out trapped platoon agents first, and the fire brigade agents will attempt to create fire breaks to contain the spread of fires. A simple messaging protocol has been established that allows sharing of information and requests for help.

6.1 Future work

While the performance of the Team Black Sheep agents has been encouraging, there remains a great deal of work to be done. Among the identified problems are difficulties with communication due to the limited bandwidth available, poor handling of traffic jams and the “grass is greener” effect - fire brigade agents in particular will “bounce” from one fire to another due to their limited knowledge of the world. A distant fire may look smaller, and hence easier to extinguish, than a close fire simply because the agent does not know that the fire has spread. This remains an open problem.

References

1. Fireman Sam. http://www.firemansam.co.uk (2003)
2. New Zealand Film Archive. http://www.filmarchive.org.nz/collections/collections_images.html (2003)