Cambridge Robotics RoboCup Virtual Rescue Simulation

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Abstract. Rescue simulation provides an effective means of developing robotic techniques, searching strategies and victim detection methods. RoboCup Rescue Virtual Simulation uses ROS and Gazebo to enable advanced multi-agent robotic simulation allowing simulation of rescue situations. It allows the inclusion of multiple types of robots including land and air based robots with a wide range of sensors and actuators. This paper presents a short review of the approach and system developed for the RoboCup Rescue Virtual Simulation challenge and future work to be completed. In particular, we are focusing on using learning techniques to allow robust detection of victims and achieving multi-agent collaboration between land and air based robots. This is the first year of participation of this team in the RoboCup Rescue Virtual Simulation.

1 Introduction

The application of robots to disaster areas is acknowledged as one area where robotics has the ability to make a significant impact [10] as it limits the risk to human agents and allows entry and exploration of areas and environment which are not suitable for humans. Despite the significant advantages much of the research in this area is challenging due to the harshness of the environment, the inability to recreate such situations and the need for robots to perform with high reliability in high stakes situations. Rescue simulation provides a platform for testing many of the major developing and principles of robotic rescue [2]. To explore these areas RoboCup Rescue Agent Simulation provides the ideal platform to test and develop principles behind rescue simulation.

The virtual robot competition uses Gazebo and ROS to allow the simulation of varying disaster environments. Within this, land and air based robot agents can be simulated. A variety of different sensors can be used within this and the placement and integration of these can be varied.

This is our first year of competition in RoboCup Rescue Virtual Simulation; we are grateful to the work published by other teams which has been extremely benefical in understanding the challenge and also the material developed by the 'Future of Rescue Simulation' workshop.

In particular, we are focusing on victim detection and how to increase the robustness, and the co-operation and interaction between the multiple agents, specifically land and air based systems. Thus far we have simple mapping and exploration utilising both air and land based robots tested and have implemented vision systems for victim detection. Further work is still required to improve the efficiency of the exploration and improve the victim detection.

1.1 Robots and System Overview

Each robot uses a different ROS core, two types of robot are used - a wheeled Pioneer robot and an aerial robot. The robots are fitted with a number of sensors for searching and localisation (GPS, laser scanner and ultrasound sensor) in addition to an RGB camera for autonomous detection of victims and also to aid when the robots when the are controlled by a human operator.

1.2 Code Base

The overall code base developed utilises ROS, with a simple structure developed with each robot forming its own ROS core and a range of different ROS modules used, with relevant messages and topics created to share and manage the relevant information. To allow manual control a simple UI has been created to allow the sensor feedback to be observed and such that key input can be used for manual control.

2 Robot & Overall Strategy

We are using multi-robot co-operation to achieve efficient and effective mapping of the area. Land based agents will be used to undertake more low level searching, however a joint map will be built up firstly using UAVs and land based vehicles to allow a more rapid rescue, after which the land based robots can be dispatched to the victims. All robots can be controlled autonomously using the navigation system developed, or manually.

All robots are equipped with GPS and in addition to this position and location with this is achieved using odometry methods to allow a more precise map to be reconstructed. Rotationally variant markers are placed on top of the floor based robots to allow their position to be observed by the aerial robots.

2.1 Searching & Mapping

The land based robots (Pioneer 3AT) are equipped with laser range finders to enable navigation and to allow for a map to built up. The ROS package gmapping is used [11]. The gmapping package provides laser-based SLAM (Simultaneous Localization and Mapping), as a ROS node (slam gmapping). Using this ROS node a 2D map can be constructed. To navigate between points on the generated map, A* searching algorithm can be used [3].

The initial method provides a simple mechanism for developing a 2D map, however, ideally 3D information would be obtained as this provides more information about the scene and would enable a higher fidelity map to be produced.

An initial simplistic approach to gaining more information about the environmental was using different robots with different heights at which the laser range finder was used, however this provides limited 3D information. To achieve a full 3D mapping system both aerial and land based systems [7] should be utilised to allow 3D localisation [4].

The long term vision is to use the aerial robots to perform a fast scan to provide a general map and identify areas where there is a higher likely-hood of victims, with the land based robots used to explore these areas. In addition to the physical mapping of the system we will add in additional information gained from the robots about a given location, for example environmental conditions (e.g. fire/water etc.) and other observations which can be made (e.g. multiple victims/blood/any other observable indication of human life). These indicators can be generated autonomously and long term will enable more focused searching of the area, but in the short term allow a human user to manually move to areas of higher priority. This method of using additional features to prioritise search areas is an area where we will apply significant focus as this allows for higher level strategy and extracts as much information as possible from the environment.

3 Victim Detection

One area which we are focusing on is the robust detection of victims in a cluttered and varied backgrounds. In emergency situations detection of victims is challenging due to variable and unknown background and potential for occlusion of the victim and the wide variety of poses which the victim could be placed in [1][5]. This is known to be a challenging problem [6], however the increasing use of neutral network for object detection can be applied for the problem of detection of items in rescue situations [9].

We believe, long term, vision systems must be developed to identify victims for real world challenges and thus the autonomous detection of victims is an important and interesting research challenge. Our proposed solution utilises RGB and thermal camera feeds and passes them through two networks one after another - a victim detection network which carries out a general sweep of the robot's view, then a classifier for the state of the victim if a victim is detected.

YOLOv2 [8] is a neural network model that takes in RGB images and performs object detection, outputting bounding boxes around detected objects in the image. We propose to use a modified lightweight version of the YOLOv2 architecture that integrates thermal information for identifying victims. There are several properties about YOLOv2 that make it particularly suited as a victim detector.

1. YOLOv2 is fast. Images are passed only once through the network, thus it is particularly suited for real-time applications
2. If trained with enough data, YOLOv2 is robust to occlusion and lighting conditions, thus can detect victims in various situations, e.g. buried partially under rubble.

3. Can be extended to detect other objects such hazardous items, street signs, other robots etc.
4. Pre-trained models of YOLOv2 are publicly available, and so transfer learning can be carried out, thus lowering the need for data collection.

The information of bounding boxes from the YOLOv2 detector will allow images of victims to be cropped and classified. A second Convolutional Neural Network trained specifically to differentiate victims is utilised on these cropped images. Classes of interest, e.g. severity of victim's wounds, types of injury etc, can be used to train the CNN. This will require a suitable dataset to be created in order to train the network for the classes of interest. Data synthesis and augmentation techniques can be used in these cases to improve robustness of the classifier while mitigating the need for large datasets.

4 Conclusions & Future Work

Initial progress has been made developing the code base and setup for rescue control and investigation system. Significant further work is now required to improve the usability, efficiency, robustness and adaptability of the system. In particular we are going to focus on:

- Improve **usability** by developing a more intuitive GUI. This will allow easier manual control of all the robots and to allow the human user to have access to all the data output from the robots (e.g. RGB feed, laser data etc.) in addition to the map produced
- Increase the **efficiency** of the searching strategy and the multi-agent cooperation
- Develop an efficient method of generating a 3D map using **3D SLAM** and optimise the integration of the aerial and floor based data
- Test the system further with a variety of different maps to understand the best division of searching in different environments
- Further investigate additional information which can be gained from the RGB data to provide information useful to prioritising areas to search

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