On Simulation of Flood and Land Slide Disaster Areas in Urban Environments for Robotized Search and Rescue

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Abstract

Every year Asian countries experience significant number of heavy rains, associated flood and landslide disasters. These may cause serious damage of infrastructure and typically result in human casualties. In order to deal with the problems that are caused by such natural disasters we suggest to develop a novel international framework, which targets to provide effective disaster response employing heterogeneous robotic teams and information collection system for a disaster site management. The information collection system targets to become a worldwide standard in the future. In order to test and verify novel concepts and algorithms a proper simulation of a disaster site and robots that are operating within this site are required. In this paper we present preliminary results of simulating a disaster site and a number of robot models in ROS Gazebo environment that are used to test the simulation quality and feasibility from the point of resources and time complexity. The presented models were constructed by the members of our research team and correspond to real robots that are used at LIRS for the project. The models were tested in the simulated environments under a number of pilot protocols for heterogeneous robotic teams' interactions.

Keywords: disaster management; heterogeneous robotic teams; simulation

Introduction

Disaster management is crucial task during and after natural or technological disasters. It includes disaster prevention, potential damage reduction, emergency response during outbreak and recovery operations after situation stabilization [1]. Large number of the operations on these stages could be effectively and safely done using special robotic systems. Urban search and rescue (USAR) robotics include wide range of robotic systems: unmanned ground robots (UGV), unmanned aerial vehicles (UAV), unmanned marine vehicles (UMV), etc. These systems may significantly differ by their appearance and functionality. Heterogeneous groups of robots combining the advantages of various robots are of interest to scientists [2]. For instance, UGVs could be designed as crawler-type robots for debris exploration; snake-like robots could be effectively used for structure inspection [3]; teleoperated construction robots could perform complex debris removal. UAVs are ideal for fast disaster site mapping and reconnaissance due to their high point of view and high movement speed [4,5]. Speed and greater autonomy of UMV make them effective in.

Efficient robot performance relays on multiple factors, which include hardware and software robustness in different conditions [6]. Such robustness could be achieved by comprehensive testing in various environments. Modern simulators require minimum efforts to create such environments and test group of robots in them [7]. However, their physics simulation capabilities are restricted and often must be expanded to meet USAR robotics requirements [8]. Gazebo simulator and Robot Operating System (ROS) are used in LIRS for these purposes with developed graphical user interfaces (GUI).

Another important goal is to integrate as much as possible robots into simulators with their unique hardware characteristics; to unify software both in simulation and on real hardware. This process is practically continuous, because robot simulation is updated every time when requirements change [9].

Robots modelling

First robot to be modelled is Servosila Engineer robot (Fig. 1). It is Russian crawler-type robot designed for urban search and rescue and demining operations. It is equipped with flippers, manipulator arm with head on its end. Head includes processing unit (Intel i7 CPU, 4 GB RAM, 32 GB flash memory), external connection devices (Wi-Fi, Ethernet, GPS) and four cameras. Two of these cameras are united into front-looking stereopair; one is optical zoom camera and last is rear-side camera. It has waterproof housing and manufacturer-provided teleoperation control. The attached 3D-printed stand is used to attach the Hokuyo laser range finder (LRF) to the robot's head.

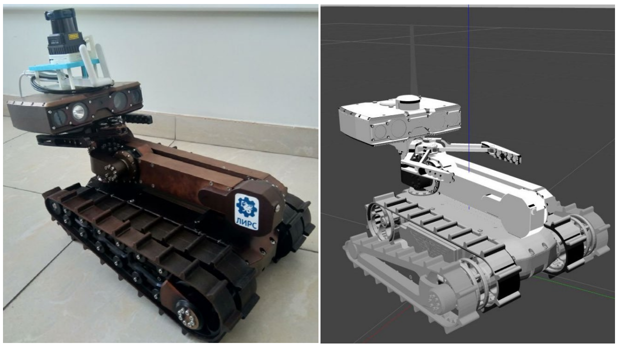

Fig.1. Servosila Engineer robot (left image) and its model in Gazebo (right image).

LIRS integrated Engineer into Robot Operating System (ROS). This integration included video streaming server development [10], movement API stabilization and ROS navigation stack configuration. Track modeling was a little difficult task in ROS. As a result, the tracks were modeled using a large number of synchronously rotating wheels [11]. Results of this integration consist of graphical user interface for the Engineer with real-time video and robot pose streaming; also, autonomous LRF-based navigation is achieved.

Next modelled robot is Junior manufactured by Avrora Robotics (Fig. 2). It is car-like robot with several sensors in it: Kinect on the front side; LRF on the top of the body; sonars for parking actions and inertial measurement unit (IMU) to control its' pose. It has Ackermann steering system and is used for autonomous car prototyping.

Fig.2. Avrora Robotics Junior robot (left image) and its model in Gazebo (right image).

None of these robots was integrated into ROS by manufacturers. However, CAD models were available and this made possible robot integration into Gazebo 3D-simulator. These CAD models were disintegrated to links and controlling joints attached to them [12]. Next, each robot's masses and inertia were transferred to simulation; thus, physical constraints are very close to reality. In addition to hardware similarity, ROS integration practically unifies software in simulation and reality.

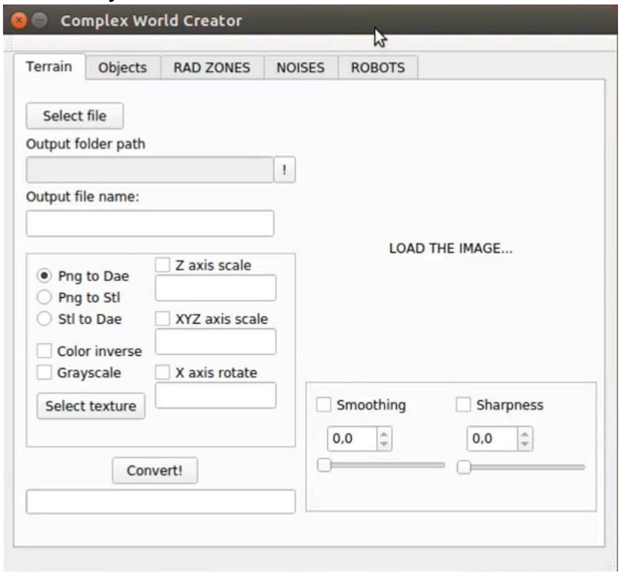

Fig.3. GUI for fast disaster site simulation.

Disaster site simulation

Simulations are essential part of robotics development. Simulated environments and robots allow testing new algorithms and methods fast and with minimum efforts. Moreover, virtual environments are stable: each new launch is strictly equal to any launch before. This feature makes simulation results robust and reproducible.

USAR robotics requires specially designed environments for simulation purposes. These environments should be tough to move and have multiple special objects on it. These objects include buildings (Fig. 4), debris (Fig. 5), radioactive pollution zones, other robots, etc.

Fig.4. Disaster site simulation with Avrora Robotics Junior robot.

Such complex environment are hard to create manually, therefore, we developed and GUI-based tool for environment creation and management (Fig. 3).

This tool creates fully operational world-file for Gazebo simulator and could be distributed between researchers easily.

Multiple complex terrains could be generated using this tool; also, various buildings (including collapsed ones) and radiation zones could be placed on the map.

The terrain of the environment is created from a black-and-white image and is a common CAD-file with the added texture [13]. The tool uses a pool of objects of the Gazebo simulator. It is possible to use your own CAD-files. The tool allows setting the coordinates of objects and their rotation angles around three axes.

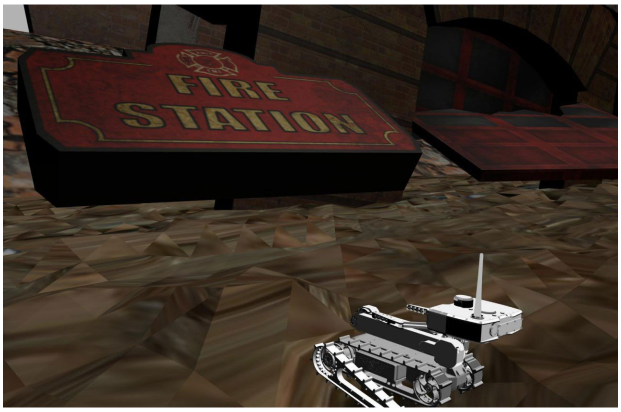

Fig.5. Disaster site simulation with Servosila Engineer.

Conclusion

USAR robotics is one of the disaster management tools. Robots of this type have very high requirements in terms of their reliability, durability and autonomy. Individual robustness could be reached by modelling robots in virtual environment and testing them in different challenging environments. Robotic group overall robustness could be significantly increased by group communication, especially in heterogeneous groups. Therefore, high quality simulations and generic interrobot communication protocols are needed to make robotic USAR more efficient and reliable. Current work in LIRS includes these research directions and they will be continued in the future.

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