DESIGN DECISIONS OF THE EROBOTICA UFCG VR TEAM ON THE CHALLENGES OF THE VIRTUAL ROBOTS RESCUE SIMULATION LEAGUE - CBR 2009

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Abstract— This paper details the eROBOTICA UFCG VR 2009 strategy to accomplish the challenges proposed by the Virtual Robots Rescue Simulation Competition at the Robocup Brazil 2009. In the previous year, our team was part of the UFCG/ITA/UNESP team(named Brasil VR at the Worldwide Championship). This partnership began with the development of a completely new controller, which was not based on any other team's architecture worldwide. For the Robocup Brazil 2009, we decided that each team would compete separately to give a more dynamic environment and make the category stronger in the country. Based on the partnership legacy the UFCG part of the consortium started to develop new functionalities and to change considerable aspects in the code architecture aiming to solve some known issues, like dependencies between interface and core. The GUI continues to be multi-platform(but is being redesigned to be more realistic and consistent to the Teleoperation and information visualization), and now is written in PyQt differentiating from the old wxWidgets approach that proved itself to contain some not interesting bugs. There is an ongoing development and implementation of a frontiers exploration algorithm to deal with the Behaviour(Exploration and Navigation) challenge.

Keywords— Rescue Robotics, Virtual Robots, Slam, Frontier Exploration, PyQt

1 Introduction

The RoboCup Rescue competitions provide benchmarks for evaluating robotic platforms usability in disaster mitigation. Research groups should demonstrate their ability to deploy a team of robots that explore a devastated area and locate victims. The Virtual Robots competition, part of the Rescue Simulation League is a platform to experiment with multi-robot algorithms for robot teams with advanced sensory and mobility capabilities. Past experiences, such as the Interchallenge League run in the Robocup Worldwide 2009 has proved that the developed algorithms may be useful for realistic applications.

2 History

eROBOTICA is a robotics research group from the Universidade Federal de Campina Grande(UFCG) that has being active in the Virtual Robots League since the year of 2007. Some of the former members from the eROBOTICA UFCG VR(2007), joined the Brasil VR joint rescue forces to participate in the Robocup Worldwide Championship in Suzhou, China (2008) and in Graz, Austria(2009). The partnership also led this team to be the Latin American Champion in the Latin American Robotic Competition (LARC 2008) in Salvador, Brazil (2008). Aiming at providing a more dynamic environment to the VR category in the country, there was a decision for the eROBOTICA team to run "solo" in this (Brazilian Robotics Competition - CBR 2009), where some of the research conducted after the worldwide championship and some of the intended future work and ideas can be challenged and discussed with the former Brasil VR consortium partners and other teams involved in this category and the competition this year.

3 Code Structure

This section details the organization aspects that were considered when designing and implementing the code that is going to be used in this year competition.

3.1 Code Architecture

In the controller, each robot runs its own control and has its own visualization tools. They also communicate among each other and to the system general visualization tool (a merged interface) through the communication station, that simulates a wireless network in the environment. In 2009 version, all our low-level code - including sockets, threads and so on - was implemented in python language. With the adopted plugin-based architecture it is possible to on-line switch the algorithms. Under this new architecture, SLAM and victims detection algorithms, for example, can now be written under any language, and loaded as a plugin in our environment. In order to support these changes and to allow a better usability to the possible human operator, the Graphical User Interface is now being written in PyQt. The machine-human communication is now designed to be based on a ergonomic interface to allow quick inspection of the robots situation. There is also integration with Joystick control(Figure 5). Monitoring tools were designed to alert the operator under specific user-defined situations or to execute specific algorithms under the same situation. All setup can be changed on-line, which is an important improvement.

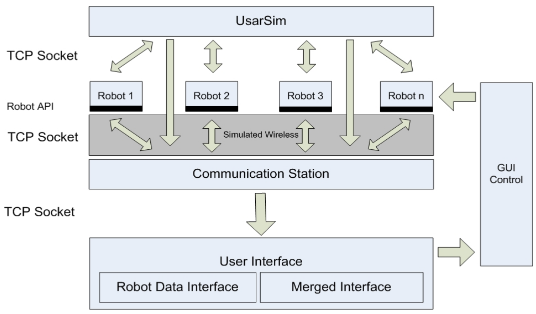


Figure 1: Controller Architecture

3.2 *Code Implementation*

Complex implementations, like Slam algorithms, demand a considerable development time to be fully implemented on some programming languages, such as C++. Therefore, the need of an adequate language to make possible our solution in a short period of time, was the main influence to the choice of Python. Python is a dynamic object-oriented programming language that can be used for many kinds of software development. It offers strong support for integration with other languages and tools, comes with extensive standard libraries, like the socket API or NumPy and Scipy(that facilitates scientific computing), and can be learned easily on a short period of time. Many Python programmers report substantial productivity gains and agree that the language encourages the development of higher quality, maintainable code. The interface was written in PyQt that is a python-binding to Qt, a cross-platform application framework to construct user interfaces.

4 Robots

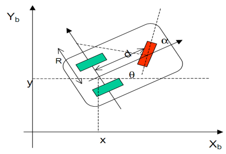
Different robot configurations could be used to explore the competition challenges. However, because of past experiences with wheeled mobile robots, this year , our team focused on three robot platforms to the competition, the p2dx (Wang and Balakirsky, 2008)(figure 3a), a 4 wheeled mobile robot from Mobile Robots Inc. and a p2at(figure 3b), from the same manufacturer. Both were equipped with Sonar, Laser , GPS, Odometer, INS, Camera, as defined on the Usarsim Manual (Wang and Balakirsky, 2008), and allowed on the competitions' rules. The third robot is an ATVRjr (Bruemmer et al., 2004) manufactured by iRobot, an all terrain 4-wheeled surveillance robot.

(a) p2DX

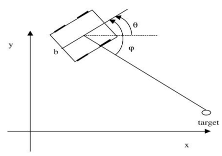
(b) p2AT

(c) ATVR-JR

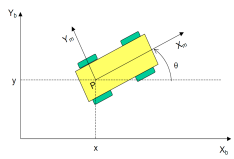
Figure 2: Used Robot Types



(a) p2DX Kinematics



(b) p2AT Kinematics



(c) ATVR-JR Kinematics

Figure 3: Robots Kinematic Models Representation

5 Exploration and Navigation

5.1 *Autonomous*

Assume that a robot equipped with a laser range scanner can build a detailed map of a previous unknown environment (Visser et al., 2008). Part of the current research is regarding frontier exploration. On the map several interesting locations can be present where the exploration can continue, referred to as exploration frontiers. Our algorithm exploits the long range of current laser scanners.

Typically, during the previous exploration a small number of laser rays already passed the frontier, but this number is too low to have major impact on the generated map. Yet, the few rays through a frontier can be used to estimate the potential information gain from unexplored area beyond the frontier (Visser et al., 2007). There is a need to absorb the maximum amount of information from the robot environment to choose its next movement. With the acquisition of information regarding the terrain, walls and possible obstacles by the robot path with Laser, there is a need to use this information to show the next step. Moreover, with an exploration algorithm based in frontiers it is possible to accomplish this task fast. Basically, a search is conducted between the explored positions and the unknown positions(called frontier point), where mapping the unknown areas is possible adding new informations to the robot map and moving the frontier point to a new region. Furthermore, the probability that this point is empty or occupied is calculated (Yamauchi, 1998).

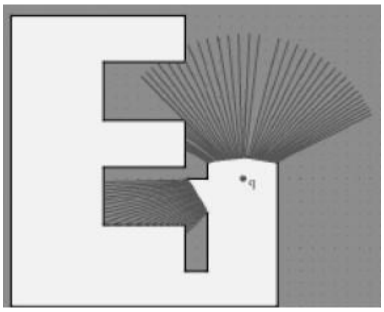
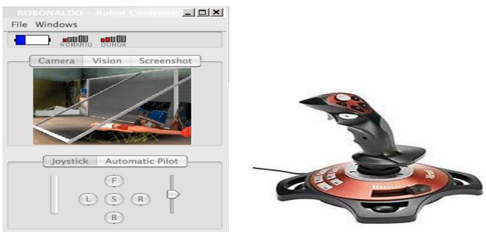


Figure 4: Frontiers Exploration

5.2 Teleoperation

Teleoperated robots are used to perform tasks that human operators cannot carry out because of the nature of the tasks themselves or the hostile nature of the working environment. (Alvarez et al., 2006)



(a) Control Teleoperation Interface (b) Joystick

Figure 5: Teleoperation Interfaces

5.3 Semiautonomous

Research into user interfaces and semiautonomous and cooperative control should enable an operator to more easily teleoperate the robot while under extreme physical and cognitive fatigue and to not miss victims or key structural defects (Murphy, 2004). This new technique for the remote guidance of mobile robots uses a shared control architecture, in which the robot's on-site sensing and reflex capacity is combined with human reasoning, analyzing, and decision making. Under tele-autonomous control, the environment conditions and the instantaneous direction of the vehicle dictate whether the operator or the vehicle takes the leading role in directing the vehicle to the target, and to what degree (Borenstein and Koren, 1990). This means that the algorithms have to be modified to generate intermediate results that are understandable and to a human operator (Lin and Kuo, 1997).

6 Localization and Mapping

We know that one of the major concerns in robot navigation is the simultaneous localization and mapping. Currently many techniques are found to solve this problem. Errors on the association of the Map References are catastrophic, being one of the major issues faced by our team on the competitions in 2008. Our actual SLAM is based on modifications on the EKF-SLAM, that consists on estimating the robot and landmarks pose using an extended Kalman Filter, where the robot position and the landmarks are correlated using a covariance matrix. We use two versions of the EKF, one based on robot kinematics model and the other based on dead-reckoning (Newman, 2006). The strategy is to use sensor fusion and parallel-running of the two versions to minimize the covariance of the error on robot pose. The careful sensor association is of great importance as it permits to eliminate accumulated errors. Moreover, the certainty of the data is guaranteed for map construction and characteristics detection. Our version currently works quite reasonably on outdoor and indoor environments, just needing some changes on the system's input. A P2AT robot was released in an environment and its true and estimated pose in the environment were recorded for some steps. The implemented algorithm in this test was the EKF SLAM with dead reckoning, with optimized covariance parameters. Figure 6 present x, y and θ errors.

7 OnGoing and Future Work

The work being carried out and the future perspectives, includes:

- `Slam`: Advance the development of the current EKF SLAM, providing some optimizations. Also, to integrate the SLAM algorithm with the Exploration and Navigation as such

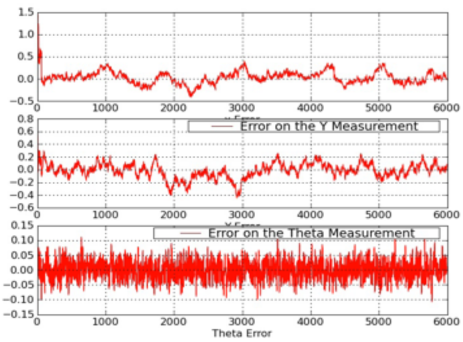


Figure 6: Measurement Error - Kalman Filter

they can enhance the quality of each other and in the SLAM case, minimize the Map errors. We are considering also implementing other techniques for solving the Slam problem such as FastSlam, UKF and SVD based Slam. Furthermore, there is an interest on using 3D SLAM techniques as they can provide a better representation of the environment.

- `Navigation and Exploration`: To implement a behaviour selector with a distinct number of behaviour types and techniques, and also to study more deepfully the issues concerning each type of behaviour and the impacts for different types of rescue situations(indoor, outdoor, etc).
- `GUI and Teleoperation`: Waypoints drawing in the map, for further robot movement and also a more ergonomically projected interface, considering all the stress and information available to an operator in the rescue context are part of the ongoing and future development for our GUI.
- `Deployment`: There is the need to implement a more robust deployment algorithm combining information from the a priori map with Mobile Wireless networks concepts as MANET and relay techniques to have a established network infrastructure.
- `Visual Detection`: Visual Detection for Victims and other important characteristics/objects in the environment.
- `Robot Platforms`: Integrate more robot platforms(AirRobot, Matilda, Kenaf) to create a heterogeneous team of robots suitable and capable to act in a vast number of situations.

Acknowledgments

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