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Control Interfaces for a Collaborative System Using LabView Package

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Abstract. In-robotics functions, performed by the software, include data acquisition, motor control, sensor signals processing, perception of objects and navigation through environment. LabView provides a solution to the limited skills and the limited time problem that appears when we use programming environments like C++ or Java. This document introduces the implementation of a communicative mobile robotic system that is based on two collaborative Pioneer robots controlled by user friendly interfaces developed in LabView. The purpose of developing this type of interfaces was to allow a complex collaborative system to adapt to any platform and be used by any type of user, without depending on his robotics knowledge level.

Keywords: mobile robots, communication mobile robots, LabView, mobile robots collaboration, interfaces

1 Introduction

The confluence of different technologies is bringing the age of robotics nearer. The number of robots used in various tasks from assembling products to detecting bombs or performing intricate surgery is increasing steadily. Used mostly in the production process, robots are finding their way into entertainment and home health care. Communication and collaboration play an important role in mobile robot systems, especially in multi-robot systems, enhanced by human to complement individual skills. In this paper we will describe a robot control system using a high level programming language (LabView, [1]). LabView was chosen as a language for controlling robots in various applications because of its ability to easily integrate hardware with software. In [2], the author presents an economical solution of a robot control system, which is based on a servo motor control card and the development of an intelligently control software. A control system implemented using an I/O board and LabView programming is used to perform the experiments on a modular robotic chain

with self-reconfiguring skills in [3]. The development of a new, more efficient and simpler control system (based on LabView) for the Scorbot ER III robot is described in [4]. LabView has been used for handling motion and vision hardware of a PC based robotic crawler built to improve the inspection of high-mast lighting towers [5]. The study in [6] discusses an application of the new Markov localization techniques in which the robot provides information to a data acquisition system including the vehicle's position, speed and data from the target. Labview receives and correlates data from the robot, the target and associated sensors in a way that the performance of every sensor can be compared.

Robolab, a programming environment based on LabView, has also been used in various applications together with a Lego robotics kit [7]. One of these applications is described in [8] and it aims to determine how Robolab can be used to satisfy science tasks in elementary schools. Another didactic application based on Robolab [9] is meant to present a realistic view of mechanical engineering to new students, and to provide them with knowledge in this area. Other papers describe algorithms developed and tested to track trajectory using a light sensor mounted on the robot, and computer vision using routines offered by Robolab.

The objective of this paper is to present the implementation of a communicative mobile robotic system that is based on two collaborative Pioneer robots controlled via LabView.

2 Contribution to Value Creation

Collaborative robotics represents multiple robotic nodes assisting each other to perform a task. Thus, multi-agent systems not only speed up complex tasks, but also increase robustness. The development of various processes is the result of changing circumstances and conditions. All these continuous changes ensure the creation of a process that leads to improved performance for the client.

Developing a novel, more accessible communication robot system, can be considered an important step towards value creation for customers using assistant robots. As opposed to the industrial robots accuracy and speed are not of prime importance in case of the assistant robots. Their purpose or function is not only to entertain, but to also render assistance, to guide, to enable communication and so on.

A good communication system between the user and the robots can enhance the capability and versatility of mobile robots. Our proposed method can address, in a simple, accessible way, all these robots, by the means of a web interface. This means that we can develop complex systems which can interact with the user using common devices (e.g. mobile phone, PocketPC).

3 Mobile Robots Communication System

The purpose of the implemented system is to control two Pioneers P3-DX robots in a real-time manner, by the means of web interfaces developed in Labview. In this paper we describe a method that realizes the remote control of a mobile robots system that

explores an unknown environment with fixed and mobile obstacles. When the robot, equipped with two driving wheels, is moving towards the target and the sensors detect an obstacle an avoiding strategy is necessary. A block diagram of the system is presented in Fig. 1.

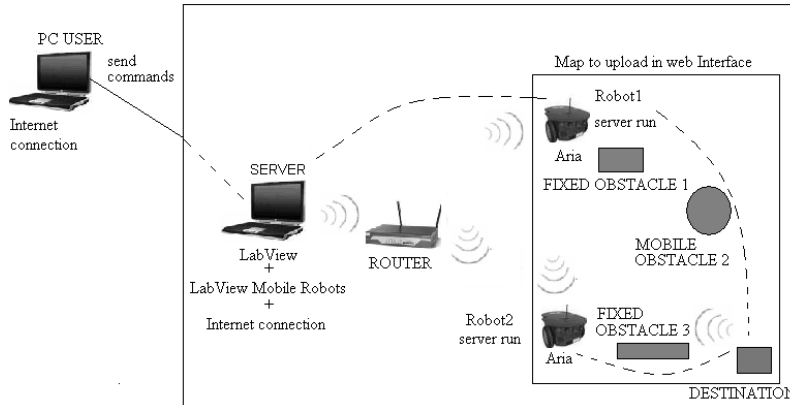


Fig. 1. Schematic representation of the system

3.1 System Architecture

The general structure of our proposed communication system between mobile robots includes the following hardware and software resources (components may be seen in Fig. 1):

- At least two remote equipments placed far away from the controller (for example any two mobile robots – in our case, we used two Pioneers P3-DX robots), able to execute the received commands;
- The features of the robots used for such a system can differ depending on what's that system was developed to do (if, for instance, we want to use the robots to manipulate objects, they will require arms to execute certain tasks). The two Pioneers P3-DX robots used by us have the following features, which allow them to move to a specific location, communicate with the user and collaborate with the other robot: mapping, teleoperation, localization, monitoring, reconnaissance, autonomous navigation and multi-robot cooperation;
- A software environment for each of the correspondents (we choose LabView with all modules related to client/server operator and server/robots), through which hardware resources can be fully exploited;
- A server used as interface between the mobile robots and the remote users;
- A Wi-Fi connection (represented by the router) that is used for communication between the system's components: the mobile robots and the server;
- An Internet connection for users connected from the terminal computers to the server. The users can control the system just by using a simple web browser interface, which is developed and presented in this paper.

3.2 Communication Algorithm Based on LabView

The communication algorithm, developed entirely in LabView programming environment, was created using a simple and user friendly interface with many guidance lines in communicating with mobile robots that can be used even by people who poses no knowledge about LabVIEW (see Fig. 2). The interface implemented in Front Panel offers the following options:

1. *Selection* of the robot IP or of the input channel port
2. *Loading* the map of the workspace on the server or locally.
3. *Displaying* the loaded map.
4. *Communicating* with the mobile robots. The user selects the end position on the map, representing robot's destination.
5. *Visualizing* robot's status, battery level and temperature.
6. *Displaying* the current state of the program and the state of execution of each task.
7. *Exiting* the application and closing the connection after task's completion.

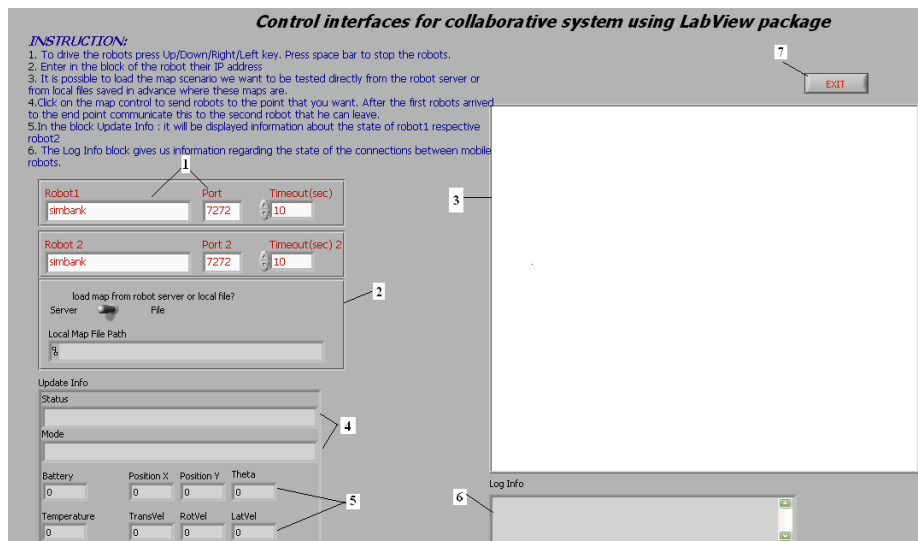


Fig. 2. Interface created in LabView-Front Panel

The communication was made according to the following principle: when the first robot reaches the destination (see Fig. 3), it tells the server that his task was accomplished. The information is then passed on to the second robot that has the same end point. This application developed in LabView runs in continuous time.

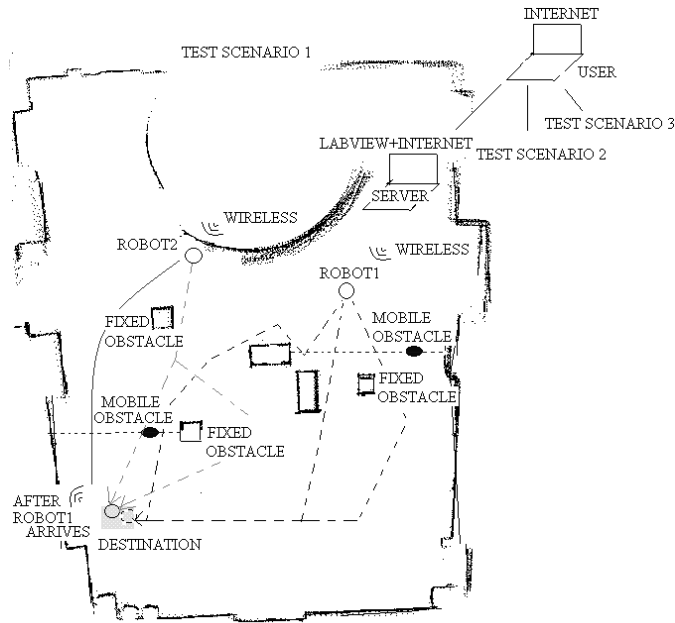


Fig. 3. The map of communication system

Behind the simple and friendly interface, subVI sites were created using the functions introduced by LabViewRobotics module, designed to communicate with any model of mobile robot. Each of the six options available in the above presented interface has been developed inside a specific subVI. Fig. 4 illustrates the part of code from Block Diagram in which, after Robot1 was identified, it is displayed on the map interface and can be commanded to go to the desired destination.

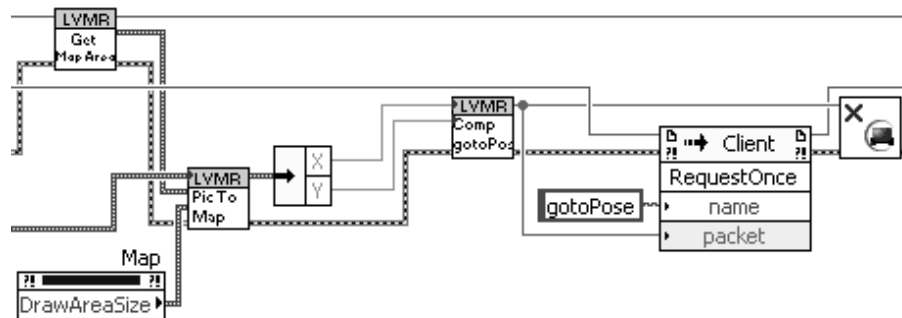


Fig. 4. Block diagram for the control of the robots

The next step is retaining the coordinates of the destination point (the “Pic to Map” subVI transforms the end location into X and Y coordinates) chosen by users, thus helping on directing Robot 1 to the desired position (using gotoPose command, known by Aria program available on robots from Mobile Robots). The connection is ended after all of the steps listed above were performed. Finally, this block ends with stopping the connection to Robot1, and then resuming itself and all of these steps for Robot2.

The connection is interrupted, using the *Exit* function, once the Robot2 reaches the destination.

4 Experiments

The conducted experiment involved two Pioneer P3-DX robots that were moving in a workspace with fixed and mobile obstacles (see Fig. 5). Fixed obstacles are represented by the white boxes, and the mobile obstacles are two AmigoBot robots that were moving on predefined paths.



Fig. 5. The experimental workspace with obstacles

A first experiment was conducted having only the fixed obstacles inside the workspace. The obtained results are listed in Table 1.

Table 1. Results obtained for navigation in the workspace with fixed obstacles

Test number	Robot1- Time(sec)	Robot 2-Time(sec)
1	36	18
2	35	20
3	39	17
4	30	17
5	33	16

By analyzing the results, it was found that Robot1 covered a distance of 8 meters in an average time of 34.6s, it communicated its final state and then Robot2 traveled a 6 meters distance to the destination in an average time of 17.6s. Tests were conducted also for the environment where mobile robots were moving along both fixed and

moving obstacles. For this experiment were used as mobile obstacles two AmigoBot robots scheduled to go on a trail which stands in the way of Pioneer robots. Results obtained for this experiment are presented in Table 2.

Table 2. Results obtained for the navigation in the workspace with fixed and moving obstacles

Test number	Robot1- Time(sec)	Robot 2-Time(sec)
1	44	27
2	38	30
3	55	32
4	48	29
5	51	29

As it can be seen from the resulting values in Table 2, we have delays up to approximately 12 seconds / robot (computed for the average values). This delay represents the necessary amount of time taken to reach destination. We want to specify that in all experimental setups we have chosen the same starting point and the same destination of the mobile robots. Even though the starting and destination point remain the same, the delays are different. This happens because the mobile robots make a random choice of route in order to avoid mobile and fixed obstacles. This random choice of route is determined by a specific algorithm (autonomous navigation), based on current position and distance between them and the obstacles (using their sensors).

5 Conclusion and Future Work

In this paper, we didn't focus on developing a complex algorithm for carrying out tasks, as shown in [10]. Instead, our goal was to test the interfaces developed in LabVIEW, which allow the remote control of a collaborative mobile robots system with customization on Pioneer P3-DX robots through a very simple way. To test the impact of such a product available online we have chosen five people, specialized in robotics, and five outsiders. Following discussions with these we found that all participants have understood the function experiment, without being compelled to request additional data.

The paper presents a web interface that allows the Internet users to test the communication between mobile robots, based on LabView packages. These resources represented an excellent tool for the implementation of our flexible communication system. The presented robotic system offers improvement over the current practice, allowing greater automation, efficiency and increased quality of data. Paths are easily configured and the experimental data is automatically collected and sent directly into an analysis software package.

Future work includes refining multi-robot motion planning algorithms to incorporate optimization criteria (including fixing real-time constraints – communication delays between user and robot). This system is ready to support further experimentation in different tasks, including different mobile robots, with

different characteristics, more complex maps: with an increased number of fixed and mobile obstacles, mobile robots using a camera for detecting obstacles instead of sensors.

We plan to extend the functionalities of this project by adding webcams in the environment in which robots are remote controlled. The human operator will have the possibility to supervise the system fulfilling the required tasks. This perspective leads to the idea of achieving a collaborative robot system that performs certain tasks in the office, car or at home. All this will be done in a virtual environment based on password access and on access lists. This application will be available on personal computers or mobile phone with Internet access.

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