Remote Monitoring and Supervisory Control of Mobile Robots Using Cellular Phones  
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Abstract

The main goal of this project is to add remote control capability of mobile robots in addition to the inverse kinematics models. It develops a visual interface that enables the operator to control the robot using his finger via a touch-screen interface of cellular phones. The operator can drive and monitor the mobile robots manually with a supervised manner. It is therefore, proposed to share the control and monitoring variables over limited Wi-Fi network for writing and reading data to/from the robot controller. In order to achieve this goal, smart real-time controller is designed and implemented upon Wheeled Mobile Robot (WMR). A standalone controller is implemented using re-configurable input output board, which enables to use Field Programmable Gate Array (FPGA) technology as well as the real time controller. The use of FPGA accelerates the control and monitoring process and helps the robot to track the pre-determined trajectories.

Introduction

With the applications in the robotics and automation, more and more it becomes necessary the development of applications based on methodologies that facilitate future modifications, up-dates and enhancements in the original projected system. Mine detection robot, one of the Automatic Control Laboratory projects (ACL-2010, College of Engineering, Jazan University), Fig.(1), had been developed in such away to scan large area within considerable time. The control system of scanning manipulator carried by mobile robot had built and implemented. The control part of the mine detection robot, is based on the microcontroller PIC 18F8520, which is used for the control process of robot steering and detection. However, the programming of complex control system was very limited due to the microcontroller capacity and performance. Design of smart embedded controller for mobile robot applications, Fig.(2), is another project of the ACL(2011) had been developed in order to extend the control and programming facilities for mobile robots by use of real-time microprocessor instead of the microcontroller, they used NI-sbRIO9631 board which have processor, (Field Programmable Gate Array) FPGA and many more (Inputs/Outputs) terminals.

Mechanical Construction

Theinitial design of the WMR was constructed using Unigraphics UGNX4 software. The mechanical structure is built with aluminum modular structures. A differential drive mechanism has been implemented with two 4″ wheels and a Omni wheel for support.

Control system

The Single Board Reconfigurable Input Output (Sb-RIO 9631) is used to implement the control system as well as to contact with the input signal via Wi-Fi network. The Sb-RIO 9631 is characterized by 266 MHz real-time processor with 1 M gate Xilinx Spartan FPGA, 110 I/O lines. It also has 64 MB of DDRAM for embedded operations and 128 MB of nonvolatile memory for program storing and data logging. The device is featured by a built-in 10/100 Mbits Ethernet port to conduct signal communication via network. Optimal Ziegler–Nichols PID control method is implemented using the FPGA module.

LabVIEW Programming

The LabVIEW program use two different modules, the Robotics and FPGA modules. The Robotics module is used to generate and introduce the command signals to the motors, as seen in Fig.(4). However the FPGA module is used to implement the PID control Algorithm. In the main VI designed for the WMR, many variables are shared and dashboard shared library is constructed. Two input variables for controlling the linear and rotational velocities of the robot. Five output variables are shared for remote monitoring and supervision. If the robot deviate about the considered trajectory, the operator can compensate the motion of the robot via his finger. The LabVIEW VI is presented in Fig. (5).

Experimental Work and Conclusion

The pre-determined trajectories are estimated regarding the considered exploration area. The inverse kinematics model is solved as presented in Fig.(4), the command signals are introduced to the electric motors. Relating to the behavior of the robot motion and supervisory monitoring, the operator can compensate the robot motion by add the correction values by his finger via the touch screen of the phone, Fig.(7).

Future Work

- Discrete identification of the motors and applying the digital PID control with feed-forward and feedback fillers should be considered.
- Expanding the range of the network and use Global Position System for controlling such mobile robots should be considered.
- Use of the developed robots in mine explorations and other applications should be tested.