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Development of a Remote Controlled Mobile Robot for Toy Application using RF Module in PIC Microcontroller

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ABSTRACT

Designed, developed and presented in this paper is a remote controlled mobile robot for toy application using RF module in PIC microcontroller. The goal of this study is to provide a reliable way of communication over a Wi-Fi network for mobile robot using Radio Frequency (RF) wireless communication module. The proponents make use of model-based task allocation method. This effective task allocation method is made possible thru central commanding computer, which realizes reliable operation for identified tasks. The proponents built a mobile robot, with capability of responding to three simple movements: forward, turn left and turn right. The proponents make use of PIC microcontroller as its control unit and it was programmed using C++. The mobile robot will communicate with a central commanding server, which is to be controlled over RF wireless communication. Through a local area network, the computer will send the command movements to the mobile robot using RF module.

KEYWORDS: mobile robot; model-based task allocation method; PIC microcontroller; RF wireless communication

1 INTRODUCTION

Undeniably, the introduction and application of robots had opened and widened horizons of advancement in varied fields. It allowed human beings to perform their tasks quickly, conveniently and safely. It then led to apprehending demand for robotics application (Y. Ota et.al, 2001). High ground adaptability is one important performance measure for the robot. In this criterion, the robot must be able to move on any uneven environment. Robot designers desired to have their robots able to move over much the same ground as humans are able to. It can be noted that robots need not only mobility, but also task-performing and supporting abilities for other tasks (Y. Ota et.al, 2001). In the field of multi-robot system, the system should assign the task for each robot. There are two task allocation methods: negotiation-based and model-based method. In negotiation-based method, the system decides which robot to perform the task by negotiation (Y. Gao & Z. Luo, 2008). In the model-based method, instead of obvious negotiation, cooperation is realized by information communication. In addition, the bot has the task-choosing model. The input of the model is the sensor data, the information among robots, and the internal states of the robot. The task choosing decision will then be the output (Y. Gao & Z. Luo, 2008).
Recognition of the dynamic environment is required for cooperative motion by multiple mobile robots. Moreover, sensing and communication ability is considered crucial for the recognition from the practical

viewpoint (S. Suzuki et.al, 1995). Suzuki, et.al in 1995 had already developed radio communication system, which enables each robotic agent to send messages to another specific agent by peer-to- peer communication, to agents within a certain group by groupcast, and to all the agents by broadcast. However, the radio communication system does not suit for local communication. In order to overcome these problems, they have developed an infra-red sensory system with local communication functionality, which enables not only detection of collisions against obstacles or other robots, but also local communication between robots (S. Suzuki et.al, 1995).
In this study, the proponents aim to provide a simple, yet convenient way of communication over a Wi-Fi network for mobile robot using Radio Frequency (RF) wireless communication module. The proponents propose an effective task allocation method thru central commanding computer to realize reliable operation for identified tasks. This study would likely apply to cooperative and performing robots. Most especially, due to its simplicity it could be most beneficial for toy robot applications.

2 MOTION CONTROL STRATEGY FOR MOBILE ROBOT

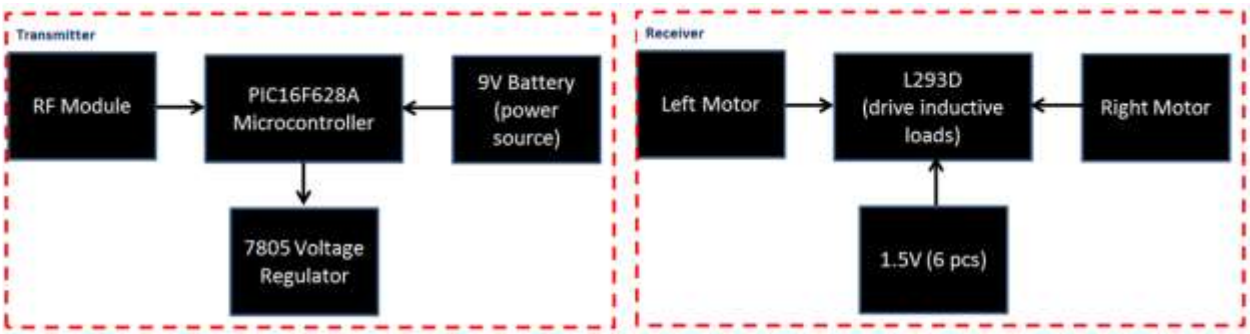

Figure 2.1: System Configuration for Mobile Robot

Figure 2.1 shows the mobile robot's system configuration. The system block diagram is further divided into two major components namely: transmitter and receiver blocks. Each block contains four sections. The transmitter sends the control signal wirelessly and the receiver receives the instruction for execution. In the transmitter block, the RF module is connected to the microcontroller and is powered by 9V battery with capacitor as battery support. The main control unit is also connected to the voltage regulator. The 7805 regulator is used to regulate the output. Thus, maintaining constant voltage of 5V. On the other hand, the received block contains the L293D, which drives inductive loads in positive-supply application. The driver drives the left and right motors of the robot. It is powered by six pieces of 1.5 V in gradual control of the movement of the DC motors.
The proponents make use of three-stage control strategy for their mobile robot. This includes the human operator, the upper computer (commanding server) and the lower computer (mobile cube robots). The operator will remotely control the system's push buttons and the commanding server will send instruction to the mobile robot using Radio Frequency (RF) via Wi-Fi network.
Generally in mobile robotics, explicit communications between robots can only be made through: an infrared beam, or a radio-frequency transmission. The first one cannot allow passing through natural obstacles like walls, closed doors, and more generally opaque objects. So only the second one can be used to ensure a safe communication. The more efficient devices use a high frequency carrier with a bandwidth more or less large (N. Hutin et.al, 1998). In due course, the proponents considered to use RF module for sending and receiving of control signals. Since the study considers transmission and reception of control signals, the remote control with three simple movements will communicate and give instruction to the

mobile robot. The robot agent is assumed of not missing any command, as two programs are developed for transmitting and receiving of control signals.

3 DESIGN CONSIDERATIONS

In order to realize a mobile robot system, which can fulfil various tasks, flexibility in hardware and software is needed. A modular approach is then adopted. The design considerations section was divided into two (2). The hardware system block diagram and the software system block diagram as shown in *figures 3.1* and *3.2* respectively.

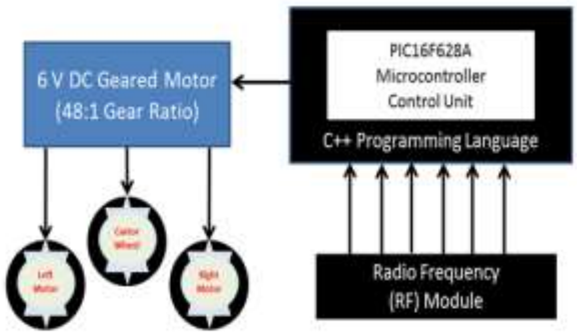

Figure 3.1: Hardware System Block Diagram

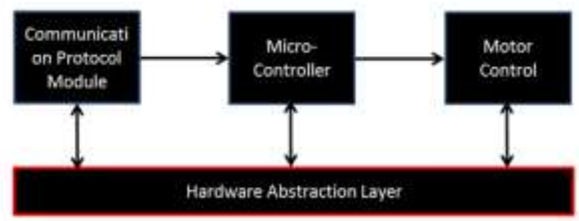

Figure 3.2: Software System Block Diagram

3.1 Teleoperation using Virtual Reality (VR) Technology

Implementing teleoperation using wireless technology to control robot remotely can significantly improve robotic system applications (N. Hutin et.al, 1998). It is then becoming a need to develop teleoperation systems, which allow full control of the robot in real environment. Sawaragi et al. investigated foundations needed in designing an interface system for robotic teleoperation. Hainsworth, on the other hand, presented a discussion of the requirements for user interfaces for teleoperation of mining vehicle systems. Zhong, et al. had adopted the virtual reality (VR) technology. Accordingly, VR technology is often used in lieu of establishing human-machine interface of teleoperation. In this technology, the operators manipulate robots on the spot by using joysticks, mouse or keyboards directly (G. Zhong et.al, 2012). In most of the studies concerning teleoperation, they regard the upper computer as a host and the lower computer as a slave. The proponents adopted this usual representation for VR teleoperation (N. Hutin et.al, 1998). As shown in *Figure 3.3*, the upper computer deals with the algorithm, decisions, and commands, while lower computer completes specific actions and sends feedback information.

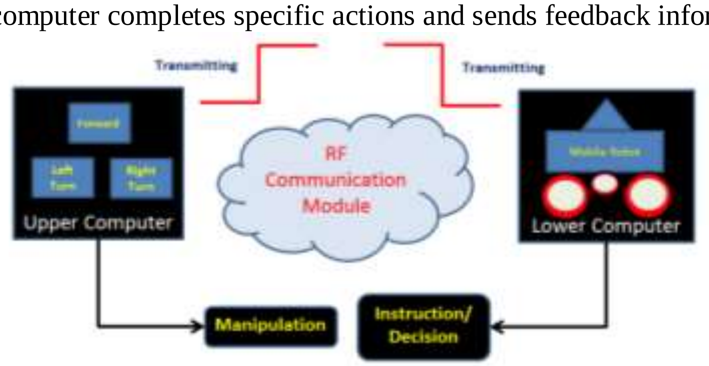

Figure 3.3: Proposed teleoperation via RF module

4 HARDWARE MODEL

The hardware part of the design is consisted of RF module embedded in PIC microcontroller, actuators, and physical structure. All of these components had to work together to give the mobile robot the ability to sense its environment and take appropriate actions. The physical structure of the mobile robot is relatively inexpensive, requires minimal tools, and is easy to build. The PIC microcontroller and the quadruple high-current half-H drivers give the proponents much of the hardware; the motors, the driver and the control circuitry, in two cheap packages. The proponents make use of PIC16F628A. It is a powerful microcontroller, which is capable of executing instructions at 200 nanoseconds. It is low-cost of high performance, CMOS, fully-static, 8-bit and 18-pin microcontroller. It is easy to program, requiring only 35 single word instructions. The proponents make use of this microcontroller to transmit control signals to the mobile robot (Web-1). In receiving the control signals sent by PIC16F28A microcontroller, the proponents make use of L293D. It is designed to provide bi-directional drive currents of up to 600-mA at voltages from 4.5 V to 36 V. In controlling the left and the right motors of the mobile robot, the proponents make use of this driver, considering that it was designed to drive inductive load, in our case, DC motors (Web-2). The robot's design is consisted of two DC motors with shivel wheel, capable of rotating 90 degrees. The mobile robot is made capable of moving vertically and horizontally on a plane. In addition, the mobile robot follows command to move from a central module or controlled button. The communication technology to be used is RF.

5 ROBOT IMPLEMENTATION

5.1 Control Mechanisms of the Mobile Robot

The movements of the robot include forward, turn left and turn right. The move space of the robot is like a grid (in terms of one grid unit forward). The wheels are fixed to its axle and not steerable. It has castor wheel in front. In order to make the robot turn left or turn right, each wheel has its own DC motor, specifically a 6V geared DC motor. To make this happen, each wheel will be attached to its own controlled bidirectional motor. For forward movement, the same control signal will be sent to both wheels. The robot is designed to be controlled over RF wireless communication. When moving forward, both wheels are driven by their corresponding DC motors. When turning left, only the right wheel is driven. The left wheel stays idle and serves as a pivot. This is the same when turning right: only the left wheel is driven and the right serves as the pivot. The proponents make use of 6V DC geared motor and Pulse Width Modulation (PWM) to reduce the average DC to slowly drive the motors. Through the use of UHF RF module, the commanding server can easily enable the start and the stop option of the motors wirelessly.

5.2 Schematics

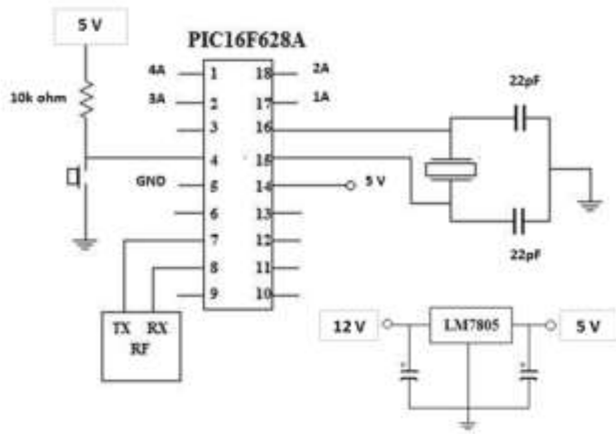

Figure 5.1: Schematic diagram of data transmission of the mobile robot

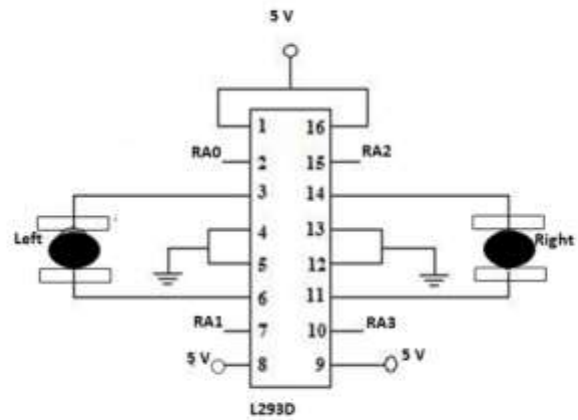

Figure 5.2: Schematic diagram of data transmission of the mobile robot

As shown in Figure 5.1, the transmit side of the RF module is connected to the pin 7 and the receive side of the RF module is connected to the pin 8 of the PIC microcontroller. On the other hand, the left and right motors of the mobile robot are connected to L293D IC as shown in Figure 5.2. The PIC microcontroller and the L293D IC were the two most important components of the system. In providing constant output voltage of 5V, the proponents make use of 7805 IC voltage regulator. Design applications of surge capacitors are taken into consideration as well in operating under severe stringent power system conditions. It prevents the equipment from damage due to voltage surges (Web-3).

5.3 Prototype

The complete mobile robot prototyping is exhibited in Figure 5.3. The transmitting and receiving side of the mobile robot (including the vital components within each module) is illustrated. By simply pressing the command button, assigned to the instruction, the mobile cube robot is controlled. There will only be three instructions known by the robot: Move Forward, Turn Left and Turn Right. The software side of the mobile robot requires two separate programs. The proponents make use of C++ language for transmission and reception of instructions from the remote control to the mobile robot.

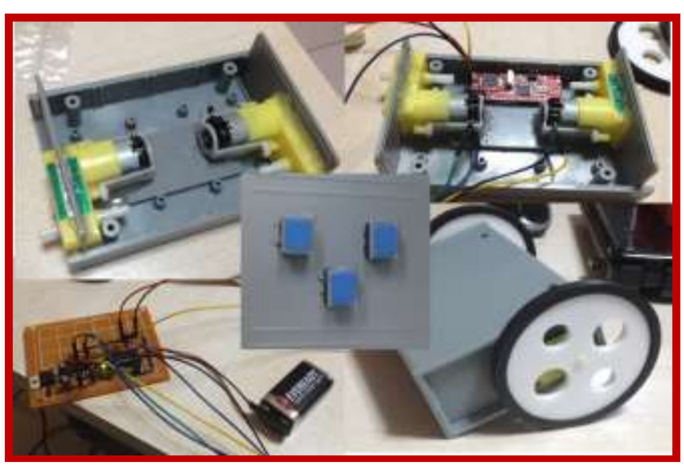

Figure 5.3: General view of the mobile robot

6 CONCLUSIONS

In this paper, a mobile robot was designed and developed. The robot has an on-board PIC microcontroller as its control unit with built-in RF module, and it was programmed using C++. The proponents make use of model-based task allocation method. The robot control makes use of three-control strategy: human operator, upper computer (commanding server) and lower computer (mobile cube bots). The proponents have shown a Virtual Reality (VR) Teleoperation communication strategy, which allows information to be exchanged between the mobile robot and its environment. Physically, this communication is based on the utilization of RF wireless communication. The mobile robot was able to communicate with a central commanding server, which is controlled using C++. Through a local area network, the computer sent the command movements (forward, turn left and turn right) to the mobile robot using RF module.

7 RECOMMENDATIONS

Considering its distance constraints, it is recommended to put an antenna wire to sense the signal significantly longer. The proponents failed to include stepper motor in their mobile due to space constraints, considering they have to observe and limit themselves on the robot dimensions. In order to make the movement of the robot finer and smoother, it is recommended to put stepper motor. Also, it would also be best if a Graphical User Interface (GUI) will be developed to effectively control the movements of the mobile robot. Future researchers can further enhance the mobile robot by adding more features and instructions. Most importantly, other communication protocols might be tried and considered as well.

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