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Wireless Remote Control of a Mobile Robot

M. Nuri Almali, Electrical and Electronic Engineering Department, Yüzüncü Yıl University
Zeve Kampüsü, Tuşba/Van, Turkey
E-mail: mna1@yyu.edu.tr

Kenan Gürçam, Electric and Energy Department, Iğdır University
Suveren Kampüsü, Iğdır, Turkey
E-mail: kenen7606@hotmail.com

Atilla Bayram, Mechanical Engineering Department, Yüzüncü Yıl University
Zeve Kampüsü, Tuşba/Van, Turkey
E-mail: atillabayram@yyu.edu.tr

Abstract - In this study, a mobile robot serving in dangerous and narrow areas for human is designed. The mobile robot consists of a mobile platform and 4-dof robot arm with a gripper. This robotic system can be controlled via either a computer based interface program or a microprocessor controlled module independently operated. The communication between the user and mobile robot is provided by transmitting wirelessly the data from a RF transmitter module to a RF receiver on the mobile platform. The user transfers the data to the USB port of the computer using the designed interface program. The control operation is performed by processing this data with a designed microcontroller board.Furthermore, the objects in the environments and direction of the mobile robot can be seen with cameras and laser LED on the robot at day and night.,

Keywords *– Communication with RF (Radio Frequencies), Remote Control*

1. INTRODUCTION

Almost everyone is familiar with the concept of robots and it's emergences as it gets more involved in our day to day lives. Recently, a considerable interest has increased for threat detection and bomb disposal which are special subjects. In this paper, many studies on this issues are examined and for this aims a mobile robot with its arm controlled wirelessly are designed and tested.

The main purpose of mobile robots is to facilitate human life and to create a healthier work opportunity in risky areas for people [1]. To fulfill such a purpose, many mobile robots have been designed in the space researches of the NASA [2].Without calibrating the camera, the control of a robot was conducted by processing the images of the environment from one or several cameras. The system is discussed in several stages which are the processing of visual information, the design of the robot and closed loop control system and the accuracy analysis when the camera location is unknown [4]. In later times, microprocessor based mobile robot designs were realized. A Z80 microprocessor based mobile robot with four wheels was designed and its motion was provided with step motors. In this study, an application of line tracking was made by a camera placed on the robot platform [4]. In another study, appropriately encoding the information entered by user via a computer software, it is sent to the robot via wireless RF module by adding the robot identifier code. After the security matching of the information to the RF module on the robot, the codes are transmitted to the microprocessor. The command is resolved by a "if-chain" and the robot performs the desired operation [5].

With the advancement of technology, mobile radio communication for mobile robot control has become a focus of attention. An IP-based robot operation system (ROS) supported by commercially available 3G mobile radio communications and a type of IEEE 802.11 local communications is used to control the unmanned air and ground mobile robot system [6]. In another study related to this subject, a military unmanned ground mobile robot is controlled wirelessly via 3G and GPS [7].

In this paper, many studies related to mobile robots have been examined and for this

Corresponding Author
M. Nuri Almali, Electrical and Electronic Engineering Department, Yüzüncü Yıl University
Zeve Kampüsü, Tuşba/Van, Turkey
E-mail: mna1@yyu.edu.tr

aim, a mobile robot with its arm controlled wirelessly is designed and tested. The design stages of this study are presented under the titles as follows.

1. The mechanical structure of the mobile robot,
2. The electronic control of the mobile robot,

a)The main electronic control board
b)RF 15 channel USB transmitter port
c)RF control circuit

3. The communication unit of the mobile robot,
4. The camera unit of the mobile robot,
5. Computer software for the mobile robot and its arm.

2. THEORICAL FOUNDATION

In this study, the control of the mobile robot is supplied simultaneously with a computer by means of RF communications technology. In accordance with the command of the user, the communications is performed that the data transformed to the computer's USB port is transmitted wirelessly to the RF receiver module on the mobile robot through a RF transmitter module. Then, the related integrates and their associated modules are controlled by transmitting the data to the microcontroller. The system block diagram is shown in Fig. 1.

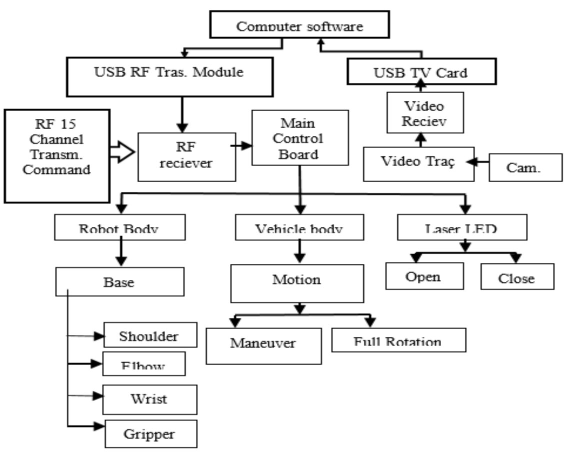

Figure 1. *Central control unite and and its interaction with interface*

The aims of the study performed are given as follows.

- Give an opportunity to the mobile robot to reach at the location to be intervened as soon as possible and in minimum error.
- Give the ability to intervene an object via the arm with 4 degrees of freedom (dof) and a gripper on the mobile robot.
- Offer an opportunity to watch the intervened place by means of wireless camera on the mobile robot arm.
- Provide a LED lightening which can be controlled wirelessly the mobile robot to be able to work in the dark.
- Design a software program to control remotely all of the modules mentioned above.

In case of an unfavorable situation for the software, free from the software, design a transmitter control circuit that can control the mobile robot with arm communicate with RF.

The mobile robot and the work order of the system are shown in Fig. 2.

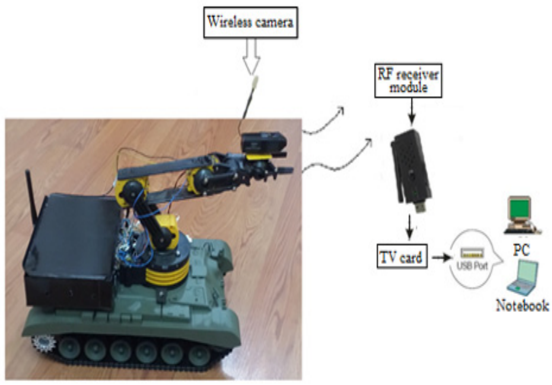

Figure 2. *The general view of the mobile robot*

The guidance of the robot with a computer or independent control is supplied to fulfill the given task like interfering an object. The communication between the robot and system is realized with RF communication system.

3. DESIGN

The mobile robot design is performed in five stages.

The first stage involves the robot arm design. The arm has 4 dof and also a gripper as shown in Fig. 3.

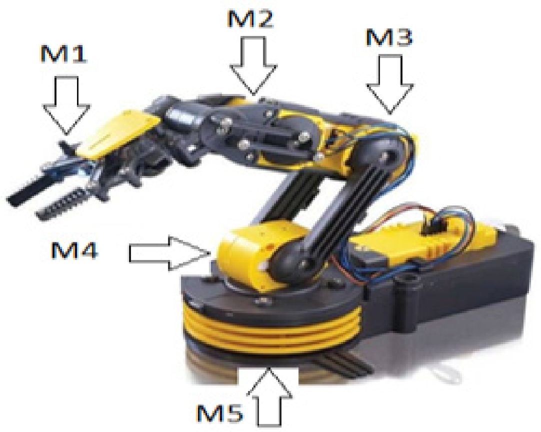

Figure 3. *The robot arm used in this study*

The working limits of the robot arm are given as. In the base, the first joint of the arm can rotate 350° about the vertical z-axis (M5). In the shoulder, the second joint can rotate 180° about a horizontal axis (M4). In the elbow, the third joint can rotate 340° about the axis which is parallel to that of M4 (M3). In the wrist, the firth joint can rotate 150° about the axis parallel to that of M3 (M2). The gripper can move in the range of 0-40mm to keep the objects.

To actuate the robot arm, 5 DC motors with 5V and their reduction boxes are used in the joints. The DC motor and gear system is shown in Fig. 4.

Figure 4. *DC motor and gear structure used in the joint of the robot*

The mobile part of the robot is chosen as a tracked vehicle (Fig. 5.) since it can move in rough terrains. 2 DC motors with 9V are used as the actuators of the vehicle. The forward-backward motion is supplied with DC motor at the rear of the vehicle and the left-right rotation maneuver is made with another DC motor at the rear. The suspension requirements of the mobile vehicle vary depending on the maximum vehicle speed and road conditions. The mobile robot can work in difficult terrains because it has a suspension and absorbing equipment minimizing vibrations on the vehicle.

Figure 5. *The tracked vehicle used in the mobile robot.*

The second stage involves three modules of the mobile robot. These modules are the main electronic control board (Fig. 6a.), the RF 15 channel USB transmitter circuit port (Fig. 6b.) and RF control circuit (Fig. 6c.) respectively. The first module can control all motions of the vehicle. The data exchange process between the computer and main control board is carried out by the second module. In the adverse case for the software program, the third module is designed to be able to run independently from the computer.

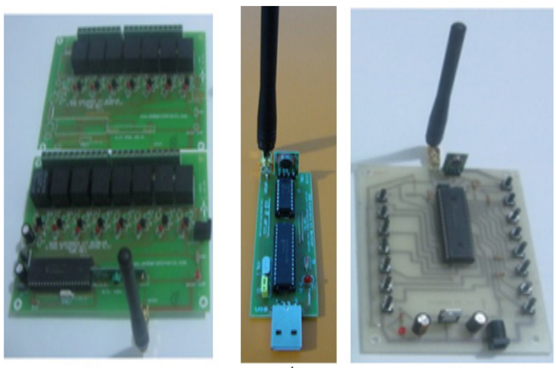

Figure 6. *a) RF 15 channel main control receiver circuit card, b) RF 15 channel USB transmitter circuit, RF 15 channel transmitter command circuit.*

In the third stage, the data transfer operation is realized with the RF communication module used on the communication module of the mobile robot. This module uses ATX-ARX receiver and transmitter modules communicating in the 433 MHz band.

In the designed mobile robot, for use

in communication, ATX-34S and ARX-34S shown in Fig.7 are used as RF receiver and transmitter modules respectively.

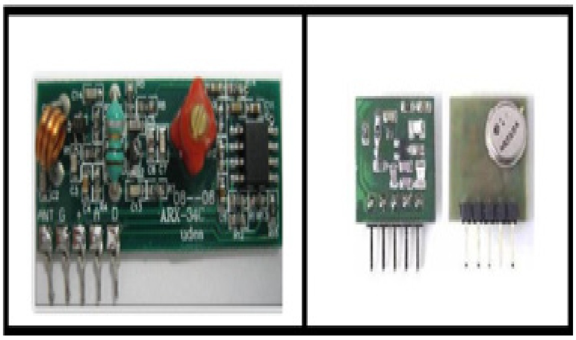

Figure 7. *ARX-34 wireless receiver and ATX-34 transmitter modules.*

The fourth stage is related to visualization. The camera placed on the robot arm has a wide freedom of the movement. This camera offers possibility to monitor a wider area since it can be moved into any region. It is communicating with the wireless RF communication technology, uses a unit which is CMOS type, wireless and rechargeable and also has capable of transmitting color video and audio up to 50-100 meters via RF signals. One of the main aims of this study is that the designed vehicle is to be used in hazardous places for human life. Thus, since it is considered that the vehicle can enter any environment, a powerful laser LED is placed on it. In the dark places, a clear image can be taken from the camera by using LED (Fig. 8).

Figure 8. *Laser LED on the mobile robot arm.*

The fifth stage contains the preparation of interface program which is easy to use and simple. Microsoft Visual Basic 6.0 was used for creating this user interface. The microprocessors are programmed by the PIC-C programming language and regulated by Microchip MPLABIDE 7.5 compiler shown in Fig. 9.

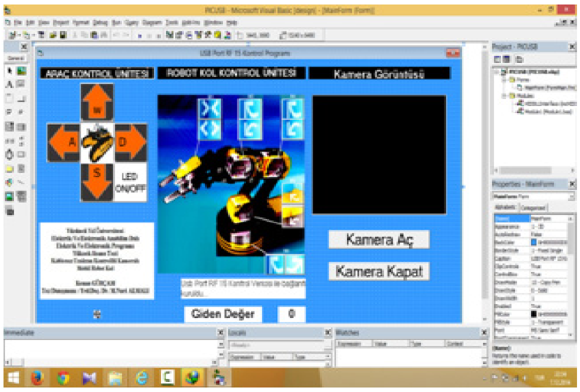

Figure 9. *The program interface created in Microsoft Visual Basic 6.0.*

4. TEST STUDY

In Fig. 10, a route is defined between two points in the plane. This route is followed by the mobile robot as depending on the user.

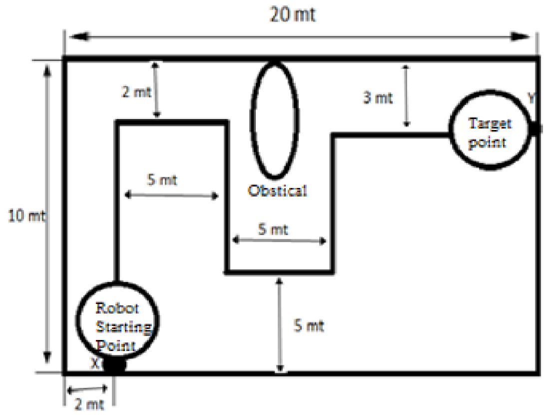

Figure 10. *The route of the mobile robot.*

Two test trails for the mobile robot are conducted by the user and the results are presented in Fig. 11.

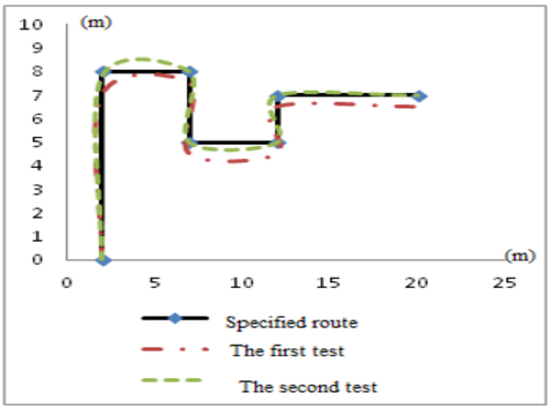

Figure 11. *The test of the mobile robot.*

The data obtained is completely user defined since the control of the robot is designed as open loop. The mastery of the user determines the results. As the number test trails increased, it was determined that the error rate decreased.

5. FINDINGS

In the process of software development for the control of the mobile robot arm, it appeared the need to develop a different control method because the microcontrollers used in earlier studies do not have enough memory and speed in calculations.

The command processing capacity of the robot or control panel directly affects the efficiency of the communication channel, the bandwidth and also speed. Therefore, an image transfer circuit is selected independently of the vehicle control board. At the design stage, the double-sided transmitting of all data in sufficient speed and reliability has a higher priority.

Previously a 4 wheel vehicle was used for the mobile part of the robot. However, in the test works, because of the lower maneuverability, it was deduced that there existed a huge amount of deviation and serious loss of time in reaching the desired targets. Instead of a 4-wheel vehicle, a tracked vehicle with higher mobility was used.

An important problem emerged at the stage of the electronic design. The extreme power need of the motors poses a problem in feeding the rest of the circuit. Due to the brushed motors without gear box used in the prototype, the motor driving operation is not carried out in sufficient efficiency. As a result of increasing the friction force with the pallet mechanism, in order sustain the motion of the robot, the motors draw much more current than usual. In this case, the power supply is overloaded to provide necessary current. Since the power from the power supply is constant, the voltage level drops down when the drawn current increases. By design, electronic cards, microcontrollers and other electronic equipment's need a non-oscillatory 5V voltage. "Dropout voltage" parameter should be taken into account since the voltage regulator, which is used in the circuit for this aim, can work as required. This parameter is the minimum voltage difference required between the input and output of the regulator. According to the parameters indicated by the manufacturer, this value must be at least 2V. Taking into account that the output voltage is 5V, the minimum voltage in the input should be greater than 7V. Because of an inadequate power, the operation of the circuit becomes unstable when the output voltage of the power supply drops below 7V.

In our application shown in Fig.12, the mobile robot arm consists of 4 joints and a gripper. Since this arm has 4 doff, one position and one orientation in 3D space cannot be controlled.

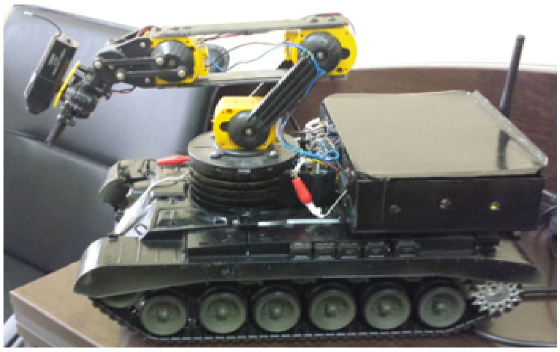

Figure 12. *The general view of mobile robot arm.*

6. RESULTS AND SUGGESTIONS

In this paper, examining the aims and functions of mobile robots made in earlier studies, we have been trying to develop more effective control methods. The designed mobile robot with its arm is controlled simultaneously by computer via RF. With the directive of the operator, the communication is supplied by transmitting the data via 15 channel RF transmitter connected to the computer's USB port and the RF receiver on the mobile robot. Then, the related integrates and modules connected to them are controlled by transmitting the data into microcontroller.

With the help of the cameras, the user can easily see the vehicle commanded which way to go. In addition, considering that the robot can enter in dark environments, a power laser LED was mounted on the arm. Since the main aim is to facilitate human life and to create a healthier working environment in risky areas, the mobile robot can be used in many areas.

Because the microcontrollers used in earlier studies did not have enough memory and speed, this has led to the need to develop different control methods. Instead of interpreting the information by the microcontroller that provides the robot control, the control can be supplied by executing all information flow on a control panel with a higher transaction capacity and just sending the commands to the robot. The system user can realize what action the mobile robot does via the computer software. Thus, the robot modules controlled with a complex integrated circuit can be controlled by a simpler one.

The project is open to improvement and will inspire future works. In adding some more features, the fields of use of the mobile robot can be extended. For example, increasing the number of camera can make it possible for larger areas to be monitored, making the gripper potable would make it possible to be operated in different areas and by adding sensors such as temperature and humidity sensors, the details of the physical environments the robot enters would be transmitted to the users.

The limits of working area of the mobile robot are closely related to especially the coverage of the RF transmitter-receiver modules. The RF on the board works 50 meters within indoor areas and 100 meters in open areas.

A RF 15 channel transmitter command module running independently from the computer program responsible for the robot control was developed. When the output voltage of the power supply falls below 7V as result of the motors used in the circuit drawing overcurrent, sufficient power for the control cards and the other electronic devices cannot be provided and the operation of all control circuits becomes unstable. This problem can be carried out by modifications. These are using brushless DC motors and reductor system, the selection of appropriate type of batteries providing higher performance and using power units running more efficiently for voltage regulation (DC-DC converter).

The data exchange is wireless and that of the environment is open to all users. This brings about security vulnerability in the system. For this reason, a specific security and protocols belonging to a Bluetooth wireless network environment can solve this problem.

Whether in the field of robotics or other technological advances, in this international area which the countries have a say in proportional to their technology, for our country, the elimination of the external dependency is of great importance. To achieve this, the transformation small-scale scientific ideas into valuable projects supported technically and financially raise an important requirement. In this regard, a conscious and systematic construction for conducted R&D works must be acquired by both state and private sectors.

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