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Remote Controlled Ground Rover for Collecting Objects and Sensing Environment

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Abstract: In this paper, three main portions of ground rover, robotic arm and base station with remote control have been designed and implemented. The ground rover provides driving on the rough paths or in places where there cannot be accessible by people for collecting objects. On this ground rover, robotic arm has been implemented to collect the objects within visible range. Temperature, humidity and gas sensors are used to sense the environment condition where the ground rover has gone. Real time sensing data can be monitored at the base station, which has been communicated through 433 MHz transmitter and receiver pair from the ground rover to the base station. Arduino microcontrollers are used as the main units of automation for the remote control system of the ground rover and base station. In addition, flash memory module is set up at PC in the base station as the backup system to store the sensing data. The main purposes for this project work are to provide detection on the environment condition and to collect the specific objects.

Keywords: Arduino microcontrollers, base station, ground rover, robotic arm, sensors

1. INTRODUCTION

In this project work, the rover is focused on ground exploration to make surveillance of the outside conditions such as ambient temperature, humanity and air pollution. Also the function of the rover is to pick the specific objects in which they can be out of reached for people. In this work, there are three portions on design and system: namely ground rover, robotic arm, and base station with RC (radio controlled) transmitter. Ground rover design provides the accessibility and movability to the specific route by the remote control. Robotic arm supports the pick and place system for the specific objects. In the system of base station with RC transmitter, it is consisted of the control system for ground rover and data backup system with the sensing information which can be monitored on PC display.

The proposed ground rover is designed and implemented with the reference of rocker–bogie suspension system which has become a proven mobility application known for its superior vehicle stability and obstacle–climbing capability [1]. In this design, there are six wheels on drive system and bogie system for travelling rough terrain and stair and obstacle climbing. For the robotic arm, it has been designed with servo motors which provide pick and place system. Through wireless communication, the information which the sensors have made surveillance on outside conditions can be observed for forecasting the environment.

2. SYSTEM ARCHITECTURE

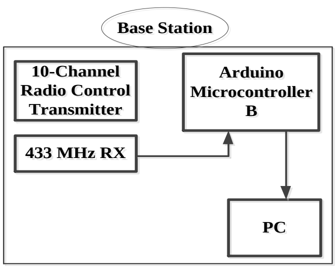

Figure 1. Proposed block diagram of base station

The system block diagrams have been described for the base station with remote control, the ground rover and the robotic arm as shown in Figure 1, Figure 2 and Figure 3.

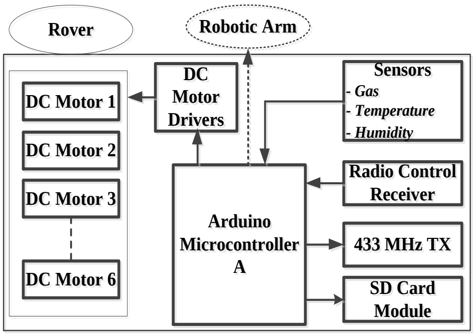

Figure 2. Proposed block diagram of ground rover

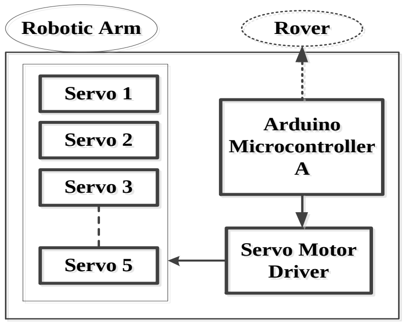

Figure 3. Proposed block diagram of robotic arm

2.1 Hardware Approach

The following components are mainly used in ground rover, robotic arm and base station with Radio Controlled (RC) transmitter. For ground rover, it is consisted of Arduino Mega 256, radio controlled receiver, RF 433MHz transmitter, DC motors and drivers, rover frame, wheels, gas sensor, temperature and humidity sensor, SD card module and SD card. In robotic arm, rotary axis, gripper, servo motors and driver are used. For base station with RC transmitter, Arduino Uno, 10–channel RC transmitter, RF 433MHz receiver and

PC. The circuit connection diagrams for the robotic arm on the ground rover are shown in Figure 4 (a) and (b).

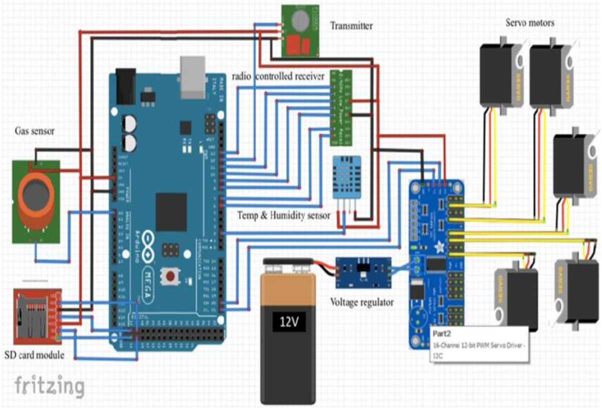

Figure 4. (a) Circuit diagram of payload system and robotic arm

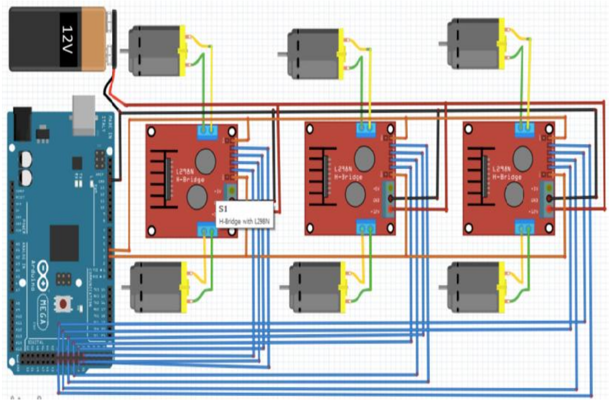

Figure 4. (b) Circuit diagram for ground rover

2.2 Programming Approach for Rover

Algorithms for rover control on the specific way have been described in Figure. 5 (a), (b), (c), (d), (e), (f) and (g) based on assigning the channel no. The existing 10 channel RC transmitter is used for rover movement in the specific direction.

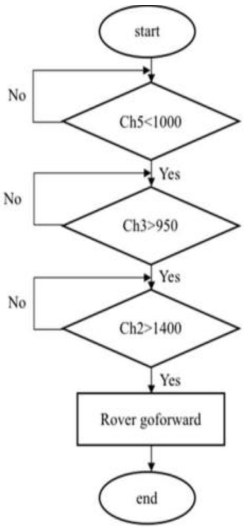

Figure 5. (a) Go forward movement

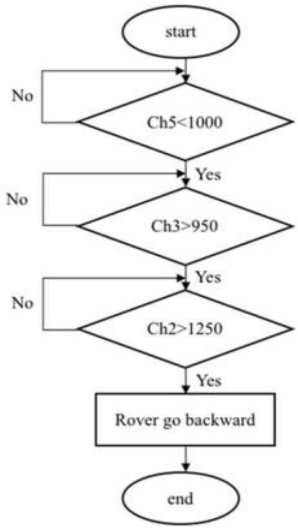

Figure 5. (b) Go backward movement

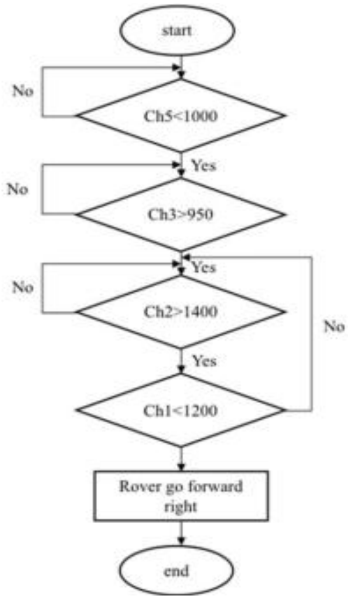

Figure 5. (c) Go forward right movement

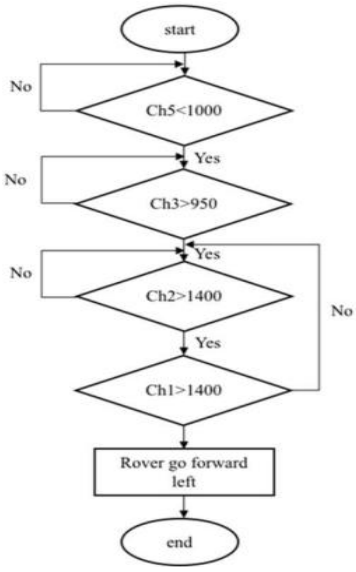

Figure 5. (d) Go forward left movement

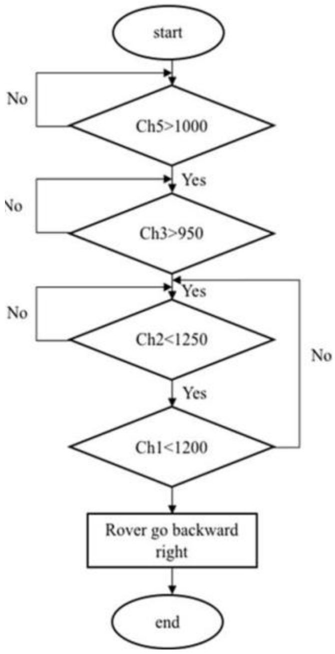

Figure 5. (e) Go backward right movement

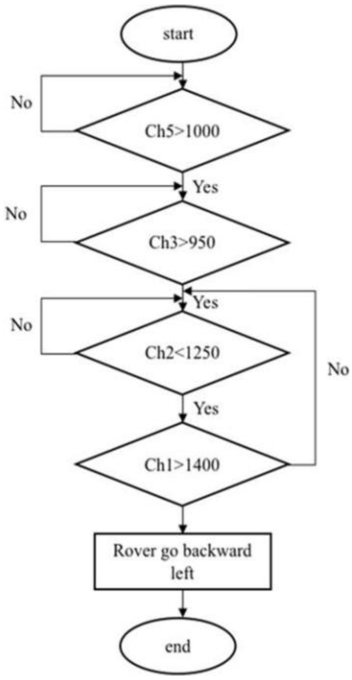

Figure 5. (f) Go backward left movement

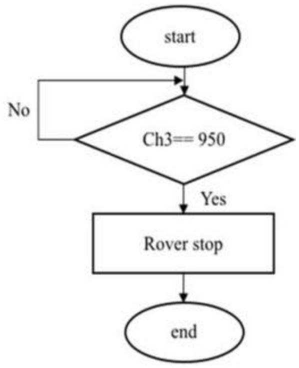

Figure 5. (g) Flowchart for rover stop

3. DESIGN AND IMPLEMENTATION

The 10-channel radio controlled transmitter is used for rover movement, robotic arm and switching on/off data storing and sending. The required channel mode (channel-5 throttle at center, or up or down position) can be selected to drive the rover or controlling the robotic arm or store and send data. For rover driving (throttle down), while channel-2 is used for forward and backward movement, channel-1 is used for turning left and right. Channel-3 is used for speed control for rover movement. When the rover is reached to the specific destination, robotic arm is used to collect the object.

For robotic arm controlling, after making selection mode with channel 5 (throttle up), channel-1 is used to rotate the robotic arm, channel-6 and channel-8 are arranged for up/down movement of robotic arm of upper axis and lower axis, channel-2 is assigned for gripper up/down movement, and channel-3 is assigned for gripping objects. Channel-9 is used to switch on and off for data sending and storing.

For stop position of the rover, channel-5 throttle must be placed at the center.

With the help of sensors: gas, temperature and humidity sensors, the user has to be aware of the environment condition that is possibly difficult to be accessible for people. If channel-9 is switched on, these sensing data are transmitted. When transmission process of sensor data is interrupted with out of long range, the data has already stored in SD card as backup system.

3.1 Rover Design and Selection of Wheels

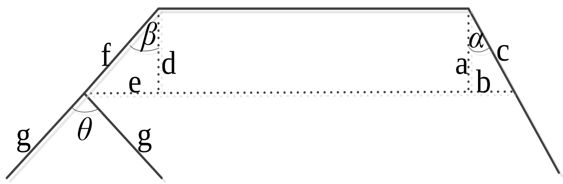

Figure 6. Proposed frame design of rover

For $\theta = 90^\circ$, let the length of g make equal. Let a = 7 in, b = 5 in, d = 7 in and e = 7 in. To find the joint angle of α and β, it must be known the lengths of the rover frame. By Pythagoras theorem, the length of c is 8.6 in and f is 9.9 in which make the joint angle $\alpha = 35.5^\circ$ and $\beta = 45^\circ$.

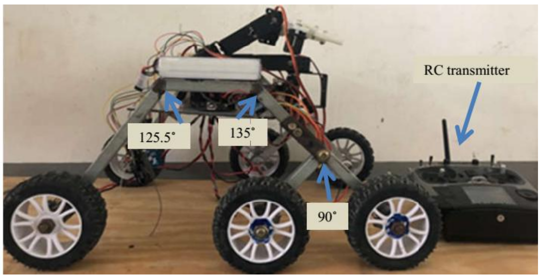

Figure 7. Ground rover

Selection of wheel is the case of consideration in rover mobilization system. Wheels used in the rover must be light weight, less friction and durable. Point design of tire is the important for passing over the terrain and hilly condition. In this project work, wheels that are reliable with this rover have been implemented. Wheels in this rover are tubeless type and there is no pressure between tire and ring. Diameter of wheel used in this rover is about 4.5 inches and width of the wheel is about 1.5 inches.

3.2 Robotic Arm Design

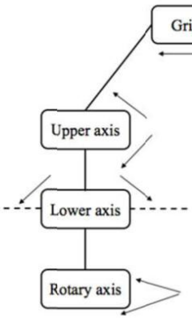

Figure 8. Robotic arm design

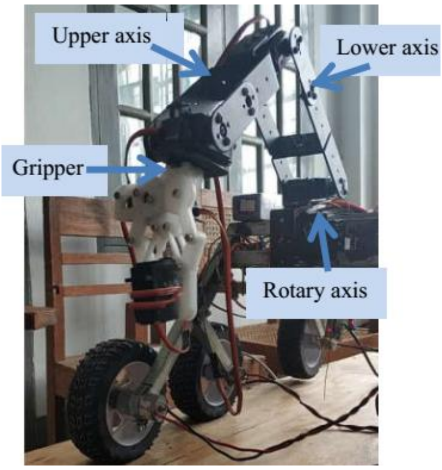

Figure 9. Robotic arm design

For the robot arm design, the length of lower axis is approximately 15.5 cm and the length from the upper axis to the gripper is 25.5 cm. When the Metal Gear (MG 996R) servo motor is used, the torque is 9.4 kg-cm [11]. To calculate the required torque for axes, the following equation can be used.

Torque = weight x length (distance) (1)

The total weight of upper axis (including servo motors associated with servo brackets and accessories) to gripper = 302 g

The total torque = 302 x 25.5 = 7.7 kg-cm

Torque of MG 996R servo motor (9.4 kg-cm) has greater torque required for upper axis.
Total weight of lower axis and upper axis to gripper = 360 g
Torque required for lower axis = weight x length
= 360 x 15.5
= 5.58 kg-cm (no load condition)

4. TEST AND RESULTS

The test weight of picking the object can be considered as the following.
Torque required for lower axis (no load condition)
= 5.58 kg-cm
Servo torque = 9.94 kg-cm
Net torque (Load) = 9.94 – 5.58
= 3.82 kg-cm
Net Weight = net torque/robot arm length (lower + upper axis)
= 3.82 kgcm/41 cm = 93.17 g

Thus, robot arm supports 93.17 g of load. In this project work, testing weight for robot arm is 55g of servo as a sample object.

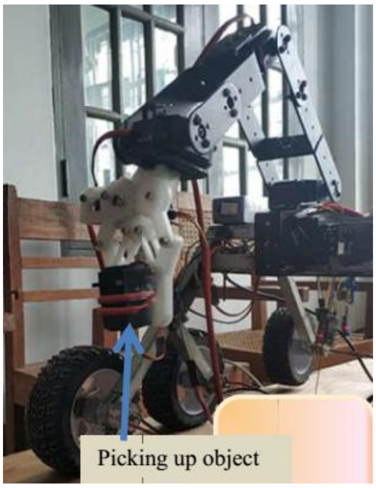

Figure 10. Picking up the mass of 55 g

For the climbing test, it has been observed the rover can climbling up and down the stairs with the height of 6 in each. In addition, this rover can travell through rough path as shown in Figure 11.

Figure 11. Travelling through the rough path

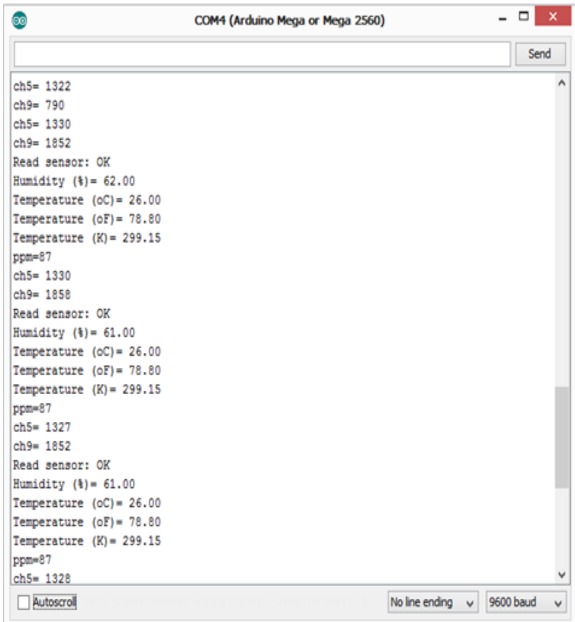

Figure 12. Storing and transmitting data test

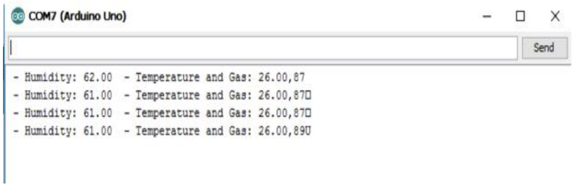

Figure 13. Receiving sensing data at base station

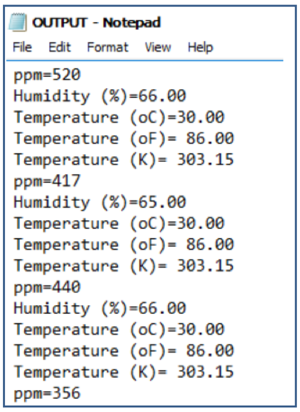

Figure 14. Record sensing data in SD card

Figure 12 shows the sensing information of the environment condition from the gas sensor, temperature and humidity sensor which is implemented in the rover. Receiving data of sensing at the base station is shown in Figure 13 and storing data file as the notepad format has been recorded as back up data system in Figure 14.

5. DISCUSSION AND CONCLUSIONS

This project work is the innovative result of combinations the rover, robotic arm and data handling system of exploration research. Especially, rover design is referenced to the simplex rocker-bogie suspension system and it has been implemented six wheels which is more reliable for cruising rough terrain than conventional four-wheel drive system. This rover can easily climb up stairs or obstacle higher than about 8 inches.

This rover operates not only sensing data with the help of sensors but also collecting objects with the help of robotic arm. On According to testing on picking up object, the robotic arm on this rover can lift up to the mass of 90 g. Then, temperature, moisture and gas data can be provided in sensing system. In addition, it has been designed that the sensing data can transmit to the base station in real time.

6. ACKNOWLEDGMENTS

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