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# Development of Low Cost Wireless All-Terrain Robot

K. Ginimav[1], J. Chaudhari[2], P. Dagade[3]

[1, 2,3] *Electronics Engineering,AISSMS's Institute of Information Technology,Pune, Maharashtra, India*

***ABSTRACT****—The paper presents the development and implementation of prototype of RF module mounted over a robot which is used to travel on uneven surface, usually called as an All-Terrain Vehicular Robot. The conditions preferably needed for the robot to work are in rough conditions, surfaces such as obstacles and surfaces with uneven travel conditions. The major challenge in the working of the robot is its stabilization and balance. The use of Rocker-Bogie mechanism helps in maintaining the balance of the robot. This makes the robot an All-Terrain Vehicle and a multi-specialty robot which can be used for various applications. The advantage of 6 wheel drive gives it better stability to avoid obstacles. The robot consists of a RF module of 2.4 GHz frequency to communicate between the user and the robot, a mobile camera acts as a video transmission device to the user during long distance operations. The multi-specialty system of an all-terrain vehicle is a prototype which can be implemented easily at a low cost, making it efficient to implement.*

***Keywords—*** *RF Module, All-Terrain Vehicle, RF controlled robot, uneven surface, Rocker-Bogie, Wheeled Mobile Robot*

## I. INTRODUCTION

The main task of the robot is to travel on uneven surfaces. These types of conditions are present on various types of land, rough roads and inclined roads. These also include places where human interaction with the surrounding environment is difficult. The areas falling under these categories are bio-hazardous areas such as chemical factories, medicine manufacturing plants, nuclear plants and discrete areas. The major field of expertise of such robots is in space explorations such as Field Rovers and outdoor tasks.

The RF module used in this robot is used for communication between the robot and the controller of the robot.. The robots used in such cases are also called as WMRs (Wheeled Mobile Robots).

The Rocker-Bogie mechanism helps the robot to have a stable balance due to its six wheels. The frame of the mechanism is unique according to the stability factors. The wheels connected to the frame are the main component for the better stability of the robot.

## II. LITERATURE SURVEY

The implementation of the RF based robot has been prepared for various applications such as cleaning the floor of the area where it is allocated by showing visuals to the user [1]. The application of this is usually for domestic purpose. The structure consists of 4 wheels, which is an important drawback considering uneven surfaces.

The robot used for environmental survey in the chemically hazardous places where human hands cannot be reached, along with radioactive zones, disaster hit sites, etc. [2]

Control of the robot by the user using 2 RF trans-receiver circuits for the application of hybrid feedback control system [3]

The base reference for this project is from the rocker bogie mechanism used for space applications in planetary rover designs. [4]

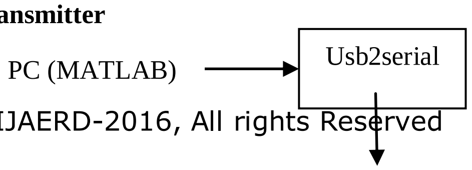
Limitations of Existing Technology:

The technologies used in the systems are based on individual application purposes. All the systems have only 4 wheel drive systems and single applications such as cleaning, surveying or exploratory missions. Developing a 6 wheel drive for rocker bogie and transforming it into multi-specialty robot is the need of the time.

## III. DEVELOPED PROTOTYPE

The prototype of the rocker-bogie mechanism using RF communication system has been developed for supporting multiple applications which can be used in various terrains.
The Block Diagram of the developed prototype is as follows:

**Transmitter**



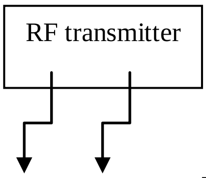
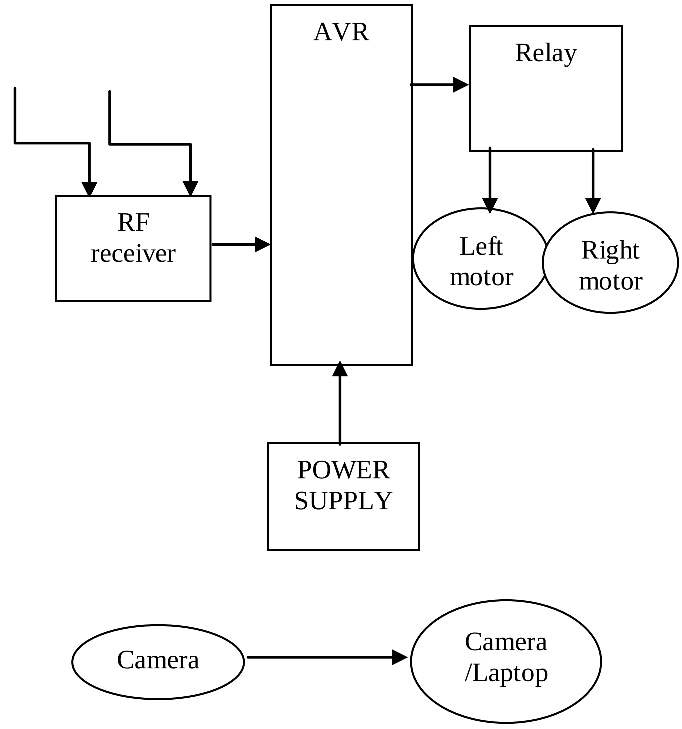



**Fig. 1(a): Block Diagram**

**ROBOT SECTION**

**Receiver**




VISION SYSTEM IP WEBCAM

**Fig. 1(b): Block Diagram**

The RF module used in this prototype is a well-established circuit. It is based on 3 wire digital serial interface and an entire Phase-Locked Loop (PLL) for precise local oscillator generation .so the frequency could be setting. It can be use in UART / NRZ / Manchester encoding / decoding. It is a high performance and low cost module. The limitations of the DTMF technology have been overcome. Network problems of the DTMF circuit have impact on the control of the robot, if the network error occurs; the robot continues to travel until the network is again established. In the RF module the robot stops as soon as the signal is cutoff.

The relays are used to drive the motors and give the vehicle motion according to the tabs used in Matlab. 6 wheels and motors have been used which are operated by the relay switching functions.

The Microcontroller is used to control the switching of relays and the display data on the 16*2 LCD. The LCD displays the operation being carried out.

An IP web based camera is used as a base function to operate on uneven surface. A mobile phone is mounted on the top of the vehicle and the video is transmitted and streamed on the laptop. The Wi-Fi hotspot is used to transmit the data. The mobile camera mounted over the top of the robot ensures proper vision while the activities of the robot are in progress.

## IV. MECHANICAL DESIGN

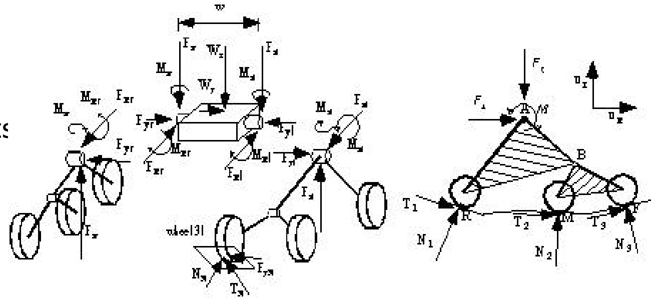


**Fig. 2: Mechanism of Rocker-Bogie**

The Rocker–bogie mechanism provides better stability during the travel path of the robot. All the minor obstacles are overcome by this mechanism.

The normal and the tangential forces between the i$^{th}$ wheel and ground are $N_i$ and $T_i$ respectively, see Fig. 2[4]

Assuming that the vehicle roll angle is small, the transverse forces acting at the wheel contact point ($F_{y1}$ to $F_{y6}$) will be relatively small. Further, by assuming that each of these forces has the same magnitude, $M_{xl}$, $M_{xr}$, $M_{zl}$ and $M_{zr}$ can be computed (the width of each of the rocker-bogie assembly is small as compared to the width and height of the vehicle, hence $M_{xl}$, $M_{xr}$, $M_{zl}$ and $M_{zr}$ are only function of $F_{yi}$). The resulting equations of static equilibrium for the body are:

$$F_{xr} + F_{xl} = 0$$
$$(F_{xr} - F_{xl})\, w/2 + M_{zr} + M_{zl} = 0$$
$$F_{zr} + F_{zl} - W_z = 0$$
$$(F_{zl} - F_{zr})\, w/2 + M_{xr} + M_{xl} = 0$$

The system of equations permits the values $F_x$, $F_z$, $M_y$ that are applied from the body to each rocker to be calculated. These forces and moments are then considered inputs to the planar problem shown in Fig. 3. The equations of equilibrium in the planar case are:

$$\Sigma \mathbf{F} \cdot \mathbf{u_x} = \sum_{i=3}^{i=1} (\mathbf{T_i} + \mathbf{N_i}) \cdot \mathbf{u_x} + F_x = 0\ )$$

$$\Sigma \mathbf{F} \cdot \mathbf{u_z} = \sum_{i=3}^{i=1} (\mathbf{T_i} + \mathbf{N_i}) \cdot \mathbf{u_z} - F_z = 0$$

$$\Sigma \mathbf{M_y},\ body = \mathbf{T_1} \times \mathbf{RA} + \mathbf{N_1} \times \mathbf{RA} + \mathbf{T_2} \times \mathbf{MA} + \mathbf{N_2} \times \mathbf{MA} + \mathbf{T_3} \times \mathbf{FA} + \mathbf{N_3} \times \mathbf{FA} + \mathbf{M_y} = \mathbf{0}$$

$$\Sigma \mathbf{M_y},\ bogie = \mathbf{T_2} \times \mathbf{MB} + \mathbf{N_2} \times \mathbf{MB} + \mathbf{T_3} \times \mathbf{FB} + \mathbf{N_3} \times \mathbf{FB} = \mathbf{0}$$

These equations are solved with the following constraints on the wheel torques:

1) $\mathbf{T_i} \le \mu \mathbf{N_i}$: no slip i$^{th}$ wheel (or will just slip).
2) $N_i \ge 0$ insures i$^{th}$ wheel ground contact.
3) $\tau_i \le \tau$ max to insure the i$_{th}$ wheel motor does not saturate.
where $t_i$ is the i$^{th}$ wheel motor torque.
Note that $t_i$ is related to the wheel tangential force $T_i$ by the wheel radius. [4]

Hence the use of the rocker-bogie mechanism is more favorable.

The wheels of the rocker-bogie mechanism can overcome the minor obstacles by balancing on either of the wheels, even if one of the wheels does touch the ground due to an obstacle. The frame of the prototype is made up of acrylic sheet, which makes the system even lighter. The placement of wheels is in such a way that all the wheels will be in a synchronous movement. Due the lightweight of the robot, it can be operated hazel-free.

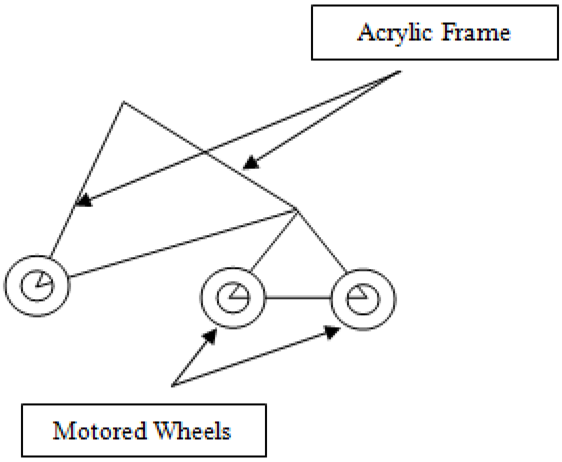



**Fig. 3: Mechanical Structure**

## V. SOFTWARE DESIGN AND ALGORITHM

The RF robot is controlled with the help of MATLAB GUI used for controlling the directions of the robot. The interface consists of the steering of the robot according to the path (left, right, straight, reverse). The relays are used to run the motors in the respective direction. On pressing the respective buttons (5, 6, 7, 8, 9) the robot will stop or move in forward, reverse, left and right. The RF (Radio Frequency) transmitter-receiver pair of sensors is used for the communication wirelessly with the MATLAB interface.

## VI. TESTS AND RESULTS

Various tests based on the motion of the vehicle have been carried out. The vehicle successfully overcomes the obstacles in its path. For around 100 times the vehicle has been tested on various terrains of ground and the vehicle has passed for over 85% of times. The results of the robot were satisfactory considering the motion of the robot.

The RF module practically transmits data over a range of 15 meters. The use of Wi-Fi hotspot from the in-built function has been used to connect the mobile camera and laptop and stream the video data.

The smart phone used transmits the video over a distance of 12 meters. The transmission of video is clear and in sync until the distance of about 10 meters and it starts to lag from later onwards.

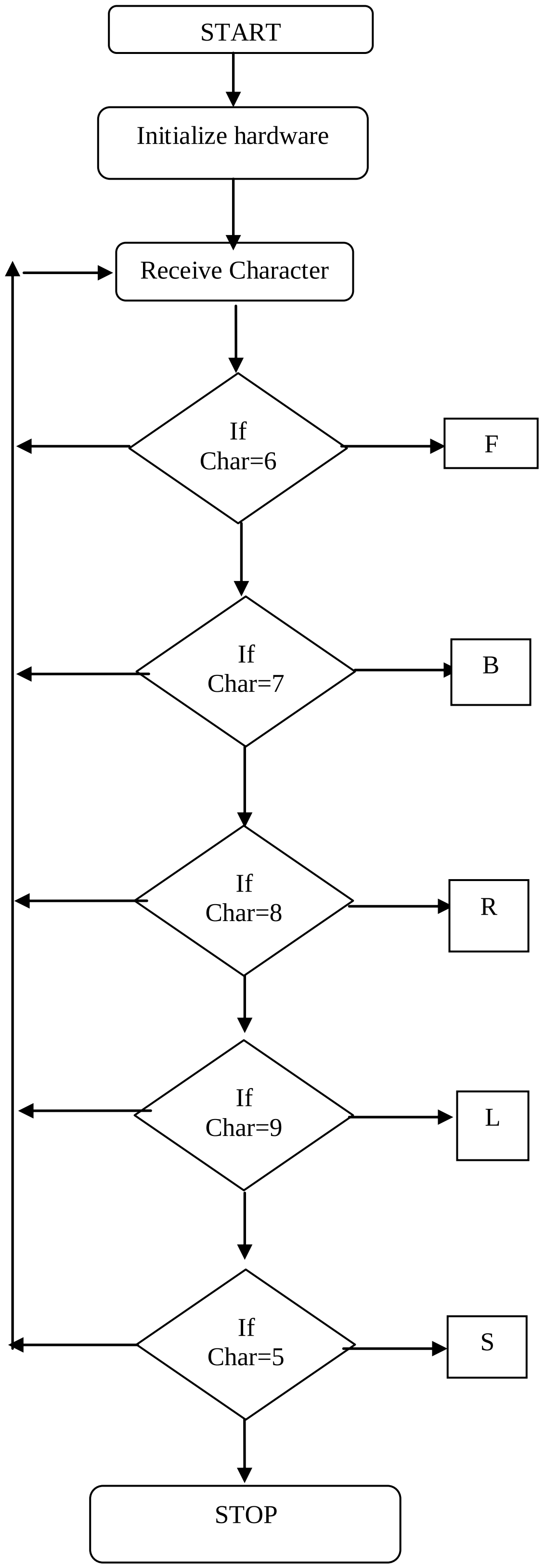



**Fig. 4: Algorithm**

## VII. CONCLUSION

The developed prototype of multi-functional wireless All Terrain Robot is a low cost solution as compared to existing developed prototypes. The selection of components like use of acrylic material for the frame, use of relays instead of L293d for the motors and various components like use of mobile camera instead of web camera has reduced the cost efficiently. The robot being a multi-specialty vehicle can be used for various outdoor applications and space exploratory systems where the surface is very uneven. The rocker-bogie mechanism successfully helps to overcome obstacles in the path of the robot. Various applications can be mounted based on the purposes the robot is to be used; here the IP web camera is used to transmit video signals to the user. Depending on the application the robot can be used for mines detection, surveillance, space exploration and bio hazardous environments where human involvement cannot be risked.

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