RAKSHAK – Border Surveillance Rover

Group 6

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Contents

Abstract

RAKSHAK is an unmanned rover for surveillance along border for security purpose using camera and thermal imaging sensor to reduce casualties of army personnel. RAKSHAK uses eight wheels rocker bogie mechanism for an all terrain movement. Camera is mounted on rover for live video streaming of border for detection of any intrusion. Thermal imaging sensor differentiates between individuals and surroundings through temperature difference. This rover is controlled by an individual at the control centre by using Bluetooth module or micro-controller and data is transferred to command control centre by wireless transmission. A local server is created on IIT Mandi's WiFi using Raspberry-Pi so that authorities can access the data using Internet Protocol (I.P.) address.

Chapters:-

1) *Introduction:* Introduction justifies and highlights the problem posed, defines the topic and explains the aim and scope of the work presented in the report. It also highlights the significant contributions from the investigation.

2) *Review of Literature:* Review of Literature presents a critical appraisal of the previous work published in the literature pertaining to the topic of the investigation.

3) *Present Investigation:* Present Investigation gives the detailed solution to the problem posed, including detailed overview of the mechanisms, circuit diagrams, IP configurations, specifications and the various processes and materials required for the project.

4) *Results and Discussions:* This is the penultimate chapter of the thesis and includes a thorough evaluation of the investigation carried out and brings out the contributions from the study. The discussion logically leads to inferences and conclusions as well as scope for possible further future work.

5) *Conclusion:* A brief report of the work carried out from the first part of the Chapter. Conclusions derived from the logical analysis presented in the Results and Discussions Chapter are presented and clearly enumerated, each point stated separately. Scope for future work is stated lucidly in the last part of the chapter.

List of Tables and Figures

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Chapter 1

Introduction

1.1   Problem Statement

The main problem this project aims to tackle is security of international borders of the country. Right now, most of the international borders of India are guarded by army personnel of Central Armed Police Forces. Securing the border all day is by itself a very hectic task. The harsh climate conditions across the border add to the misery of the guarding soldiers. Also, there is and always will be a high risk of loss of life as well as human errors when army personnel guard the borders.

Coming to another fundamental job of the soldiers, sneak and spying operations of enemy bases. During sneak and spying operations, the soldiers are exposed to extremely dangerous conditions, especially those in the vanguard, entering into the enemy bases/camps. Above anything else, the life of an individual (in this case a soldier) should be given the top priority and the main aim should be to complete the tasks with minimum loss of lives.

1.2   Aim

RAKSHAK, the proposed prototype, is a border surveillance rover meant to solve the mentioned problem by replacing the soldiers guarding borders with an unmanned rover equipped with instruments to secure the borders. The rover will be able to monitor and patrol the borders across the harsh climate and rough terrain conditions.

RAKSHAK will also be beneficial for surveying battle areas and targets especially during operations such as surgical strikes. The sneak and spying operations of enemy bases can be done by using the robot in the forefront. Implementation and installation of RAKSHAK across borders or at the very least sensitive regions can help in dramatically reducing the loss of life and fatal injuries while patrolling.

1.3   Scope

India's land border covers over 15,000 km and shares boundaries with China, Pakistan, Nepal, Afghanistan, Bhutan, Myanmar and Bangladesh. The borders are complex, harsh climate conditions, hostile neighboring countries and varied terrains being the major reasons, and so border management becomes an important part of national security.

RAKSHAK can prove to be an important aspect for border management and a crucial solution to saving the valuable lives of soldiers across international borders.

Chapter 2

Review of Literature

2.1   Border Security

India's land border covers over 15,000 km and shares boundaries with China, Pakistan, Nepal, Afghanistan, Bhutan, Myanmar and Bangladesh. The borders are complex, harsh climate conditions, hostile neighboring countries and varied terrains being the major reasons, and so border management becomes an important part of national security.

2.1.1 International Borders of India

- The Northern borders of India are defined by Himalayan mountain range.
- The Western border contains mainly the Thar Desert.
- The border with Bangladesh comprises of Khasi and Mizo hills and regions defined by river Ganga and river Brahmaputra.
- Mountains in the Northern part consists mainly ice while those in the North-East may be deeply forested.

2.1.2 Safeguarding Borders

Effective border management requires proper planning and measures to safeguard the country's frontiers and keep it safe from the risks involved in the movement of goods and people across the borders. Central Armed Police Forces (CAPF) which comprises of Sashastra Seema Bal (SSB), Border Security Force (BSF), Indo Tibetan Border Police (ITBP), Assam Rifles (AR), Central Reserve Police Force (CRPF), Central Industrial Security Force (CISF) and National Security Guard (NSG) along with the Indian Army are responsible for securing India's international borders.

All states in India except Madhya Pradesh, Chhattisgarh, Jharkhand, Delhi and Haryana have an international border or a coastline. Hence, there is a vast possibility of implementing RAKSHAK, at least in very sensitive areas if not in all.

2.2 Movement of Rover

International borders, especially those of India usually have extreme weather conditions along with a rough terrain to cover. The rover needs to be able to adapt and move across the harsh terrain to meet its purpose. Therefore, the movement mechanism of the rover plays a vital role for the implementation of the project. A normal 4 wheel mechanism won't be able to cope with the tough terrain and so a different approach needs to be made for the same. **Rocker Bogie Mechanism** is one such alternative for better movement of the rover.

2.3 Camera Height

The main job of RAKSHAK is to 'look' and report everything happening along the border to officials present in a control centre, i.e., the rover needs to record and stream everything around it, thus arising the need to use a camera. As already mentioned, the Indian International Borders cover a variety of geographical environments, a fixed camera would be a hindrance to proper coverage. Hence, the camera height needs to be adjustable according to the will of the user and the surroundings and circumstances around the rover. This can be done in many ways, according to research and this project uses a screw-driven scissor lift mechanism for this purpose.

2.4 Streaming of Data and sensor control

The data recorded by the rover, mainly in the form of video, needs to be transmitted wirelessly to the concerned authority so that they could take the required action as quickly as possible in case of any emergency/critical situation. For the same, a minicomputer of sorts is required to coordinate with the transmission of the data wirelessly; Raspberry pi comes in use at this point. The Raspberry pi was also chosen due to the additional need of rotating motors for the movement of the rover as per the will of the user and also for providing commands to the sensors (camera rotation etc.) according to the desire of the user.

Chapter 3

Present Investigation

3.1 Rocker Bogie Mechanism

Rocker bogie suspension design has made its name in mobility of rovers by providing superior stability and obstacle-climbing capability. The Rocker bogie mechanism was an obvious choice for Mars Exploration Rover as well. The design has no stub axles or springs for the wheels, which allows the rover to climb over any obstacles coming in the way of the rover, even those twice the size of the wheels. All the wheels remain on ground at all times, contributing to the stability of the robot.

3.1.1 Working Principle

The main reason why the chassis a rocker bogie suspension climbs over the obstacles coming in its way is because the design has no springs or stub axles for the wheels. The proposed system's tilt stability is limited by the height of the centre of gravity of the entire rover. Another purpose of the mechanism is minimizing shocks and damage to the rover when climbing over any obstacle. The mechanism is designed to be implemented for low speed use.

3.1.2 Design of Rocker Bogie Rover

Dimensions of the linkages and angles between them are an important factor for this mechanism. As such an 8 wheel rocker bogie mechanism has been chosen for the project. An advantage of 8-wheel mechanism over the conventional 6-wheel mechanism is that it provides better stability during relative high speed movements of the rover.

The box containing all sensors, wiring and raspberry pi is made of metal sheets riveted together. The linkages are made by cutting PVC pipe pieces for a light body structure, washers are used to ensure free movement of all linkages and wheels.

3.1.3 Dimensions

- Height:
- Width: 33.5 cm
- Total Length: 62 cm
- Length of one linkage (wheel to wheel): 25 cm
- Length of Linkage connector: 37 cm
- Angle of Linkages: 90°
- Wheel diameter: 10 cm
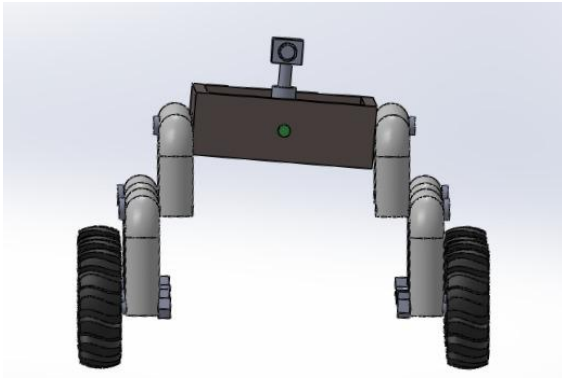- Box Dimensions: 30cm x 25cm x 5 cm
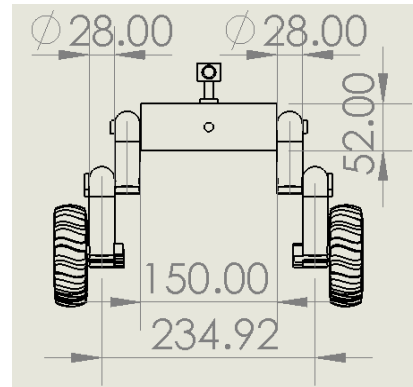

Fig 3.1(a) Front view of rover

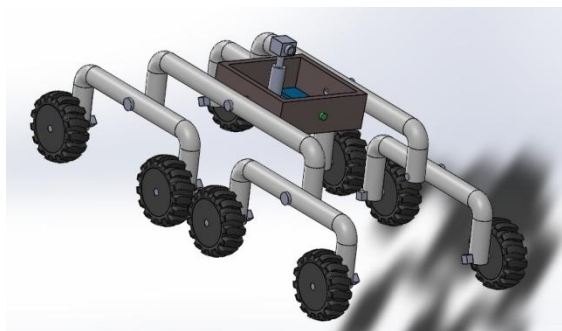Fig 3.1(b) Dimensions from front view

Fig 3.2(a) Side view of rover

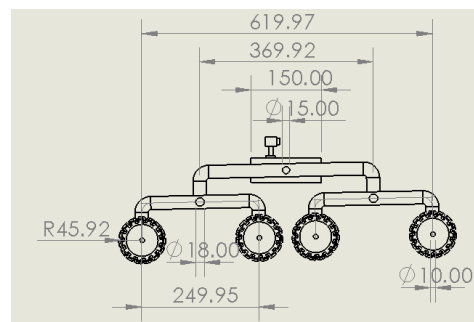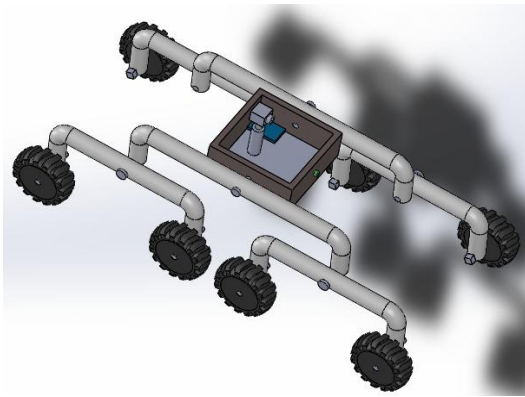
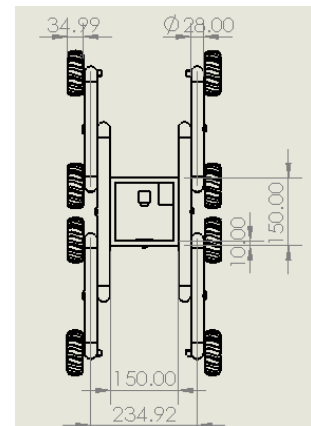Fig 3.2(b) Dimensions from side view

Fig 3.3(a) Top view of rover

Fig 3.3(b) Dimensions from top view

All dimensions in above figures are in mm

3.2   Height Adjustment Mechanism

As mentioned in Chapter 2, the camera to be fit on the rover for visual input needs to be height adjustable according to the needs of the user and the surrounding conditions of the rover. The mechanism used for height adjustment is a scissor lift which is driven by a lead screw which in turn runs with the help of a motor. Washers are used at the intersection of 2 arms for free movement. All the arms, the base and the top are made out of wood with anti-termite, anti-water coating over it. The lead screw and rods for sliding are made of mild steel. Nuts and bolts are used to tighten all joints.

3.2.1 Dimensions

- Total Height: 80 cm
- Length of arms: 30cm
- No. of arms: Total 12, 6 on each side forming 3 pairs
- Length of Lead Screw : 30 cm
- Diameter of Lead Screw : 1.1 cm
- Base dimensions: 23 cm x 28 cm
- Top Dimensions: 23cm x 28 cm

Fig 3.4 Example of a screw-driven scissor lift

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3.3   Control of Sensors

The major inputs for surveillance are taken mainly through the night vision camera and thermal sensor. The camera is able to rotate around in all directions and provide extensive coverage along with the height adjustment mechanism. The thermal sensor differentiates a subject from its surroundings by measuring the temperature difference. Motor drivers control the speed of motors which in turn control the wheel rotation.

The commands are given to the sensors wirelessly using a Bluetooth sensor. The movement of the rover, the rotation of camera and the height adjustment are all controlled by a user wirelessly using a Bluetooth module. In return, the data captured by the sensors is displayed over a local server created presently on IIT Mandi's WiFi using raspberry-pi so that authorities can access the data using Internet Protocol (I.P.) address.

A Raspberry Pi module is used as a computer to control the proper working of sensors ensuring proper transmission of commands.

3.3.1   Working of Raspberry Pi

1. sudo apt-get update
2. sudo apt-get upgrade
3. sudo raspi-config and then go to inference ,select camera and finish.After this reboot the pi. Now, camera is enabled.
4. raspistill -o <imageName.jpg> for image in jpg format.
5. raspivid -o <videoName>.h264 -t 1000 -> 1000 means 1000 millisecond.
6. sudo apt-get install gpac ->MP4Box
7. MP4Box -add video.h264 <new_name_of_video.mp4>   -> To convert video from .h264 format to mp4 format.
8. sudo apt-get install omxplayer -> to install omxplayer
9. omxplayer -o hdmi video1.mp4 -> to play the video1 with no lags.

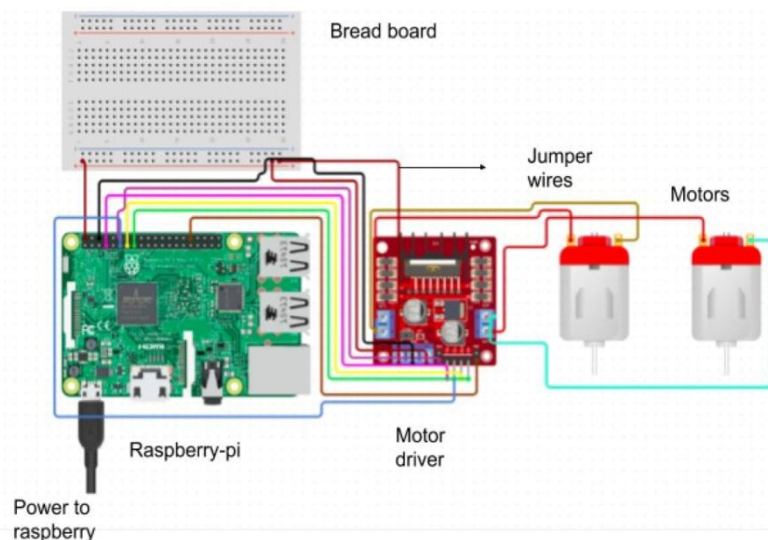### 3.3.2 Circuit Diagrams

Fig 3.5 Circuit Diagram for motors
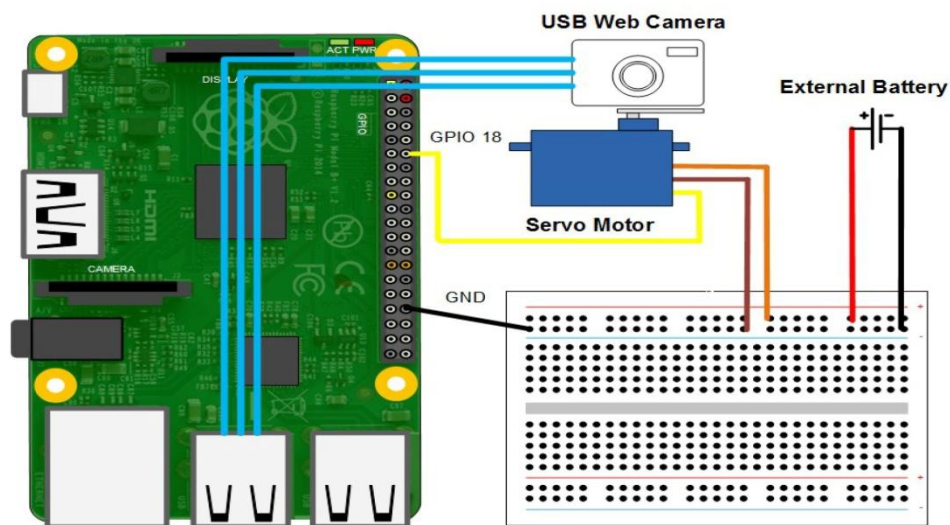
Fig 3.6 Circuit diagram for web camera
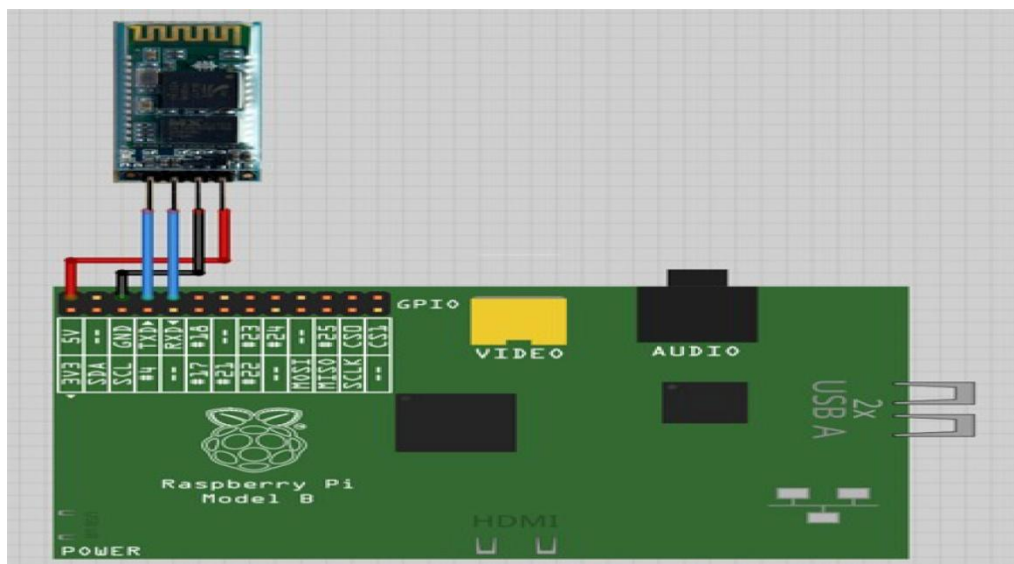
Fig 3.7 Circuit diagram for Bluetooth module

3.3.3 Websites for Live Streaming

- http://rakshak-design-practicum.herokuapp.com/
- http://rakshak-design-practicum.herokuapp.com/videoPage.html

3.4 Specifications

The following are the specifications of major components used for the project.

Table 3.1 Raspberry Pi 3B+ specifications

Product Details	Specifications
SOC Type	Broadcom BCM2837B0
Core Type	Cortex-A53 64-bit
RAM	1 GB DDR2
USB Ports	4xUSB 2.0
Wi-Fi	2.4GHz and 5GHz 802.11 b/g/n/ac
Camera Port	CSI camera port

Table 3.2 Raspberry Pi Camera ModuleV2

Product Details	Specifications
Still Resolution	8 Megapixels
Video Mode	1080p30, 720p60 and 640×480p60/90
Linux integration	V4L2 driver available
Sensor	Sony IMX219
Sensor Resolution	3280×2464 pixels
Optical size	1/4"
Focal length	3.04 mm
Horizontal field of view	62.2 degrees
Vertical field of view	48.8 degrees

Table 3.3 Home Surveillance Camera

Product Details	Specifications
Camera Type	WiFi Camera
Video Output	HDMI
Video Recording	720p @ 25fps
IR Night Vision	HD night vision
HDD Available	Yes
Viewing angle	120°
Pan/Tilt	355°

Mobile Compatibility	Android/IOS
Motion Detection	Alerts when motion is detected

Table 3.4 Bluetooth Module HC-12

Product Details	Specifications
Range	1000 m
Open Space/Baud Rate	5000 bps
Working Frequency	433.4-473 MHz
Maximum Transmitting Power	100 mW (20dBm)

Table 3.5 L298N H Bridge Motor Driver

Product Details	Specifications
Dimensions	43x43x26 mm
Minimum drive Voltage	5V
Maximum drive voltage	35V
Maximum Drive Current	2A
Maximum logic voltage	5V

Table 3.6 NRF-24 Wireless Receiver and Transmitter

Product Details	Specifications
Working Voltage	1.9-3.6 V
Transmission Speed	2Mbps
Connectivity Type	Radio Frequency
Dimensions	45x16 mm
Current Peak	45 mA (rx), 115 mA(tx)

3.5 Manufacturing/Assembly Processes involved

The entire chassis of RAKSHAK was made from scratch using raw materials. The following major processes were involved in this project:

- Cutting: Cutting wood pieces, PVC pipes etc
- Drilling: Holes at joints for
- Lathe: Smooth rods for proper sliding
- Riveting: assembling the control box

- Carpentry: Wood work for height adjusting mechanism
- Grinding: Smooth finish to products
- Threading: Of screws and holes meant for screws

3.6   Cost and Materials

The following are the materials along with their costs used for the project.

Table 3.7 Cost and Materials

S.No	Name of Item	Cost per Item	Quantity	Cost
1	PVC Pipes, connectors, Elbows, Wires	728	-	728
2	DC Motors	450	8	3600
3	L298N Dual H bridge Dc Motor Driver , Breadboard, Jumper wires	1140	-	1140
4	Bluetooth Module HC-05	329	2	658
5	Raspberry Pi	2825	1	2825
6	Arduino UNO	419	1	419
7	SD Card SanDisk 32 GB	429	1	429
8	Surveillance Camera	2000	1	2000
9	Wireless Receiver and Transmitter Module NRF-24	207	3	621
10	Printing of Digital Poster	560	1	560
11	Sliders	265	2	530
12	Joystick Module	173	2	346
13	Screws/nuts/bolts/Hose Clamps	721	-	721
14	Miscellaneous Items	308	-	308
15	Bluetooth Module HC-12	459	2	918
16	Thermal Imaging Sensor	4353	1	4353
17	Raspberry Pi Camera	690	1	690
Total Amount				**20,846**

Chapter 4

Results and Discussions

4.1 Problems Faced

- Proxy configuration of IIT Mandi WiFi for wireless transmission of data.
- Assembly of tires for Rocker- Bogie Mechanism.
- Unavailability of Aluminum cutter due to which wood had to be used for height adjustment mechanism.
- Lead screw usage in height adjustment mechanism.

4.2 Impact on Society

The product can have a revolutionizing impact on the security and surveillance system which, at present, is almost totally done using man power in our country. Unmanning the border security can prevent the loss of countless lives of soldiers while guarding international borders. The rovers deployed across the vast length of international borders can prove to be very beneficial for army surveys.

The environment won't have any major affect as the maintenance of the product can be easily done. Most of the products are non-biodegradable but their usage will be long time and hence will cause minimum damage to the environment.

A small fraction of the military fund is required for vast implementation of the rovers. The rover will help in considerably decreasing the work load on soldiers which can be deployed for other important missions/operations. The topmost priority is and should always be given to the lives of soldiers; hence the rover can have tremendous importance for the society as a whole.
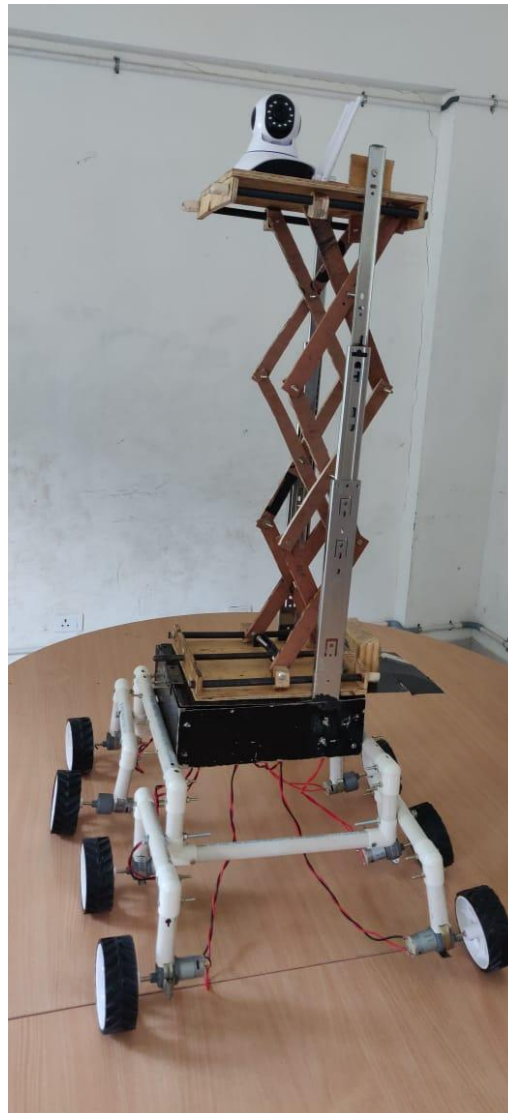
4.3   **Final Prototype**

Fig 4.1

Final Prototype

4.4   **Future Improvements**

The prototype can have the following future improvements for a better version of the product:

- Additional sensors like sonar, metal detector, gas detector etc can be mounted on the chassis of the rover for a more comprehensive survey and surveillance mechanism.

- Aluminum can be used instead of wood providing better durability and lighter body weight to the rover for the arms of screw-driven scissor lift mechanism implemented for adjusting camera height.

- Better quality of sensors and motors can be used for better range, higher efficiency and better quality of data input and processing.

- The transmission range for the communication of commands can be increased by using better quality Bluetooth sensors or even replacing the Bluetooth system with something better.

Chapter 5

Conclusion

5.1   Conclusion

The conclusion of this report is that RAKSHAK, the border surveillance rover, has fundamental applications for border security purposes and sneak and spying operations. Implementation and installation of RAKSHAK across borders or at the very least sensitive regions can help in dramatically reducing the loss of life and fatal injuries while patrolling. RAKSHAK can play an essential role in surveying battle areas and targets especially during operations such as surgical strikes. RAKSHAK will surely be an asset for the Indian army to cherish.

The surveillance can be done by the rover 24x7 in all of the rough terrain and harsh climate conditions, the only hindrance being recharging and replacing the batteries. The rover can be controlled from a safer distance while maintaining proper working of it. The Rocker Bogie suspension mechanism ensures that the rover can cover all terrains without any hindrance to its movement and provide stability to the sensors, battery and other important components present in the control box. The scissor lift mechanism which is driven by a lead screw ensures proper coverage of the area using the camera. The height adjustment mechanism provides different points of view for the user to choose from as required as per the circumstances. The camera and the thermal sensor provide extensive coverage of the area to be surveyed.

As per the future prospects, better quality cameras and thermal sensors can be used along with addition of sensors like sonar, metal detector and gas detector etc for an extensive coverage of the area. A better height adjustment system can be used to provide an even better stability and efficiency to the camera and any other sensor mounted over it, possibly pneumatics. Aluminum can be used instead of wood for more durability of the height adjustment mechanism. A better battery backup along with a cooling system can be implemented provided the prototype needs to be taken forward. Renewable energy sources can be used to recharge the battery backup.

The project has a powerful impact on the society, reducing life loss, chances of injuries and work load of the country's soldiers while also providing a helping hand for sneak and spying operations and survey missions. This will be a valuable addition to the military power.
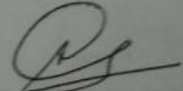
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Report - Honour Pledge

I, _Dr. Arpan Gupta_, upon my honour, hereby confirm that My Team (Team No - 6) has not plagiarised report from any source.

Signature & Date: _____ 24/5/19.

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Mentor of Group No: _6._