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"Design and Manufacturing of Rough Terrain Vehicle Using Rocker Bogie Mechanism"

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Abstract: These Rough terrain vehicles are used on irregular and rugged terrains where complex vehicles cannot reach. These vehicles in the military are used for monitoring unknown territories, observing borders, and rescue missions. Since these vehicles are exposed to hostile conditions, the fabrication and design of the vehicle should be plain and simple as to make it easier for mending and restoring. The primary mechanical feature of the vehicle is the rocker-bogie mechanism. This mechanism assists the six-wheeled vehicles to passively keep the connection to the rocky uneven terrain. There are two primary advantages of using this feature. First, the pressure of wheels is equilibrated and second, while propelling through broken and uneven surfaces all the wheels remain in contact and help to push the vehicle forward.

Keywords: Cost-effective, Defence, Long-lasting battery, Maximum stability, Rocker Bogie Mechanism, Rough Terrain, Stair Climbing.

I. INTRODUCTION

There is a rise in requirement for rough terrain vehicles that can handle formless environments with uneven terrains. These mobile robots are used for objectives that are not achievable by a human and are hazardous to human life. The rocker-bogie mechanism has demonstrated vehicle mobility to be effective because of its superior stability and its ability to overcome hurdles and obstacles. Springs and stub axles are absent for each wheel, assisting the rover further to maneuver over obstacles that are more than twice the wheel diameter, all the while keeping all 6 wheels planted on the rocky surface. Various implementations can be made of this singular design such as transportation of troops and conducting low-level reconnaissance in the military. This vehicle can be sent for exploring territories that are inaccessible by the soldiers to provide real-time visualization and data to the controller or operator. An open-source microcontroller; raspberry pi attached to this vehicle will allow it to be operated by a remote. For rescue operations and surveillance missions, a raspberry pi camera of 12.3 megapixels can capture high definition and supports videos at 720p 60 frames per second. Another application of this remote-controlled robot is to supply medical aid, food, and other urgent requirements that can deem necessary in case of an emergency or an ambush. One major drawback of the rocker-bogie vehicle is that it moves at slow speeds. This is done to maximize stability while moving over uneven terrain and to avoid the likelihood of the rover rollover due to rugged surfaces which would in the long run harm the rocker-bogie design. Complications such as navigation, mobility, and vision can marginally be affected in between missions depending on the specific scenario. Our main objective is to fabricate a simple design and develop a platform suitable for subjecting to harsh military environments. The vehicle will focus on essential features that can carry out most of the military operations and hence giving us the motivation to develop a vehicle to strengthen our military defence.

II. LITERATURE REVIEW

The basic idea of our research work is to fabricate a rocker-bogie mobility vehicle that is based on that of NASA. The rocker-bogie system keeps the 6 wheels of the vehicle planted at all times even on rocky terrains. This helps the wheels to generate traction and help in pushing and moving the vehicle in various directions. The rocker-bogie is at present NASA's preferred mechanism for rough terrain mobility robots, primarily because its distribution of workload over the 6 wheels helps it overcome obstacles and keeps the vehicle steady. It can also be used for various purposes along with operating on rough tracks and climbing hurdles. It has numerous advantages, but one drawback is the rotation of the mechanism when and where it is required. This is made possible by attaching individual motors but also causes a rise in cost and complexity in design. A rough terrain amphibious vehicle was made to provide aid on the east coast of Malaysia which faced a disastrous flood leading to huge losses to lives of people and property. The flood tracks consisted of soil, water, debris, damaged property, etc. which left the roads rocky and uneven. This put the task force in a tough spot as it wasn't practical for them to assist the damages and provide aid where necessary. The research showcased a rough terrain amphibious vehicle that could move over all terrains using the rocker-bogie suspension. Our

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quest on understanding space can be categorized as such: an aim to get closure on how the universe works, economic potential in using resources outside our planet, and space colonization. Our major interest is focused on the military, the moon, and the mars. Since these are relatively closer and do not have hostile conditions for rover vehicles, it intrigues our interest in space exploration. There are multiple similarities in the software and mechanical design that allow the vehicle to perform surface surveillance and space exploration. Autonomous planetary navigation coupled with hazard dodging make these vehicles an exceptional platform for reliable transport and carrying scientific instruments. The only minor changes involve between different missions are the scientific equipment being carried and the size of the mobility vehicle. The proposed design of the vehicle was done on SOLIDWORKS. Certain researchers discussed the concept of designing a robust stair climbing robot that could tackle stairs with overhangs. To overcome overhangs, the geometry of the periphery of the wheels is adjusted.

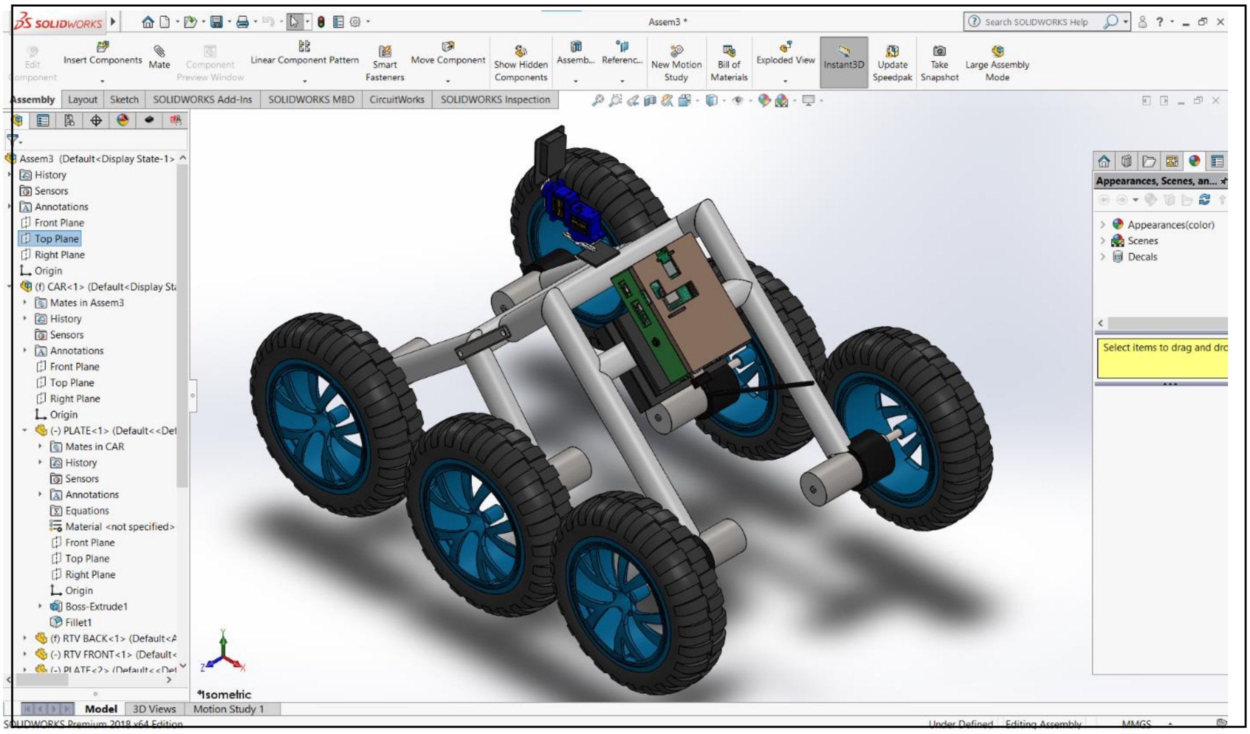

Fig. - 1

Design parameters are set to reduce performance contrast. The Grey-Based Taguchi method is acquired for supplying an optimal setting for design parameters. The fabricated prototype showcased to have performed scaling of stairs with overhangs, thus verifying the analysis conducted. A work proposed the working of a rocker-bogie system on several different surfaces taking into consideration the weights acting upon the links which determined torque applied on it. By taking an assumption of accurate stair dimensions, the vehicle overcame it with great stability. The constructed model could climb angles at a 45-degree angle. It has also experimented with a webcam with AV recording mounted at the top of the vehicle, which returned satisfactory results when tested with 360-degree wheels. When tested for tackling stairs with dimensions lesser than 15 inches, the prototype could not climb the hurdle. However, it was suggested, it is fairly easy to fabricate a vehicle that can overcome stairs with lower heights. A research paper proposed a novel design for the rocker-bogie mechanism aimed at carrying heavy loads such as military troops maintaining stability. The suggested modification shows an increase in stability and proved it through SOLIDWORKS 3D simulations. The future scopes of this vehicle are in the military as a weapon loader and performing surveillance in coal mines. The working of the system begins with its commands which are given to the raspberry pi electronic board, which are received from the operator. Once the signal is received, the electronic board passes it to the components as per instruction. The commands for movement i.e., for backward and forward are sent to the motors thus rotating the wheels accordingly. The command for capturing videos and images is sent to the raspberry pi camera, which is returned to the user to act upon it accordingly. Oftentimes, the robot could be trapped in a hurdle or muddy terrain which it cannot overcome at normal speed. This is where the servomotor attached individually to all wheels helps control the velocity and acceleration.

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III. DESIGN AND CALCULATIONS

A. *Material Selection*

- Energy-efficient: the pipes weigh less than other materials, allowing energy savings in transportation.
- Better water quality: The extraordinarily smooth surfaces of the PVC pipes make it difficult for the sediments to accumulate, unlike pipes constructed from conventional materials. Microorganisms and other contaminants have almost no chance of binding themselves into the inner walls of the pipes.
- Cost-effective: Using PVC pipes saves considerable costs when low breakage rates, installation, life cycle costs, and other related expenses are taken into account. The durability of the tubes also ensures the effectiveness of the tubes, minimizing the pipe’s maintenance costs, thereby, making it more economical over time.
- Lightweight: PVC Pipes provide an immense weight advantage against other materials for piping. The installation of PVC pipes takes less manpower and less time comparatively. PVC's abrasion resistance, lightweight, good mechanical strength, and strength are essential technical advantages for its use in building and construction applications
- Safety: Besides their longevity, PVC pipes are also safe. The non-toxic material is flame-resistant. Moreover, PVC pipes do not react with chemicals. It is because of these reasons PVC pipes are used across industries.
- Design: The properties of PVC pipes allow manufacturers and designers to design innovative solutions and products. Moreover, the versatility of the PVC pipes reflects in their wide applications. PVC can be cut, shaped, welded, and joined quickly in a variety of designs.

B. *Wheel Design and Calculation.*

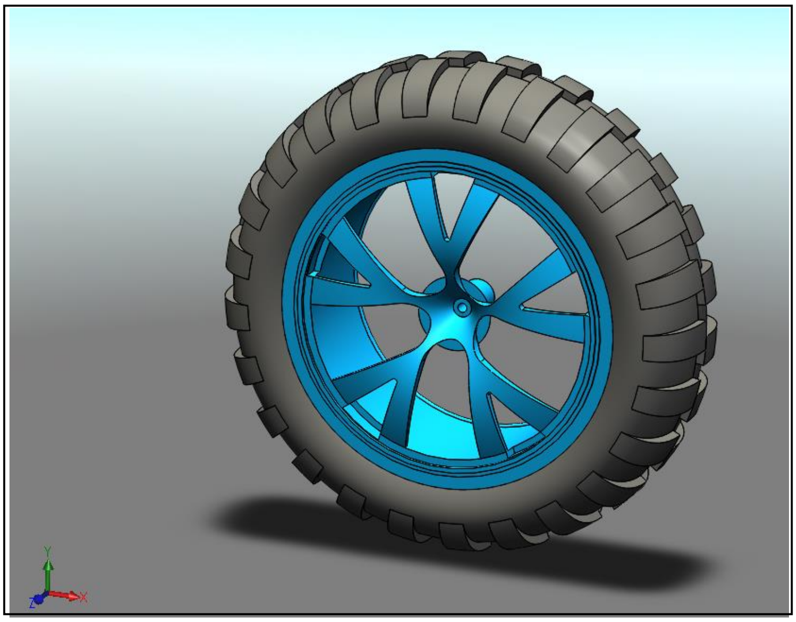

Fig. - 2

We know that,

$V = \pi D N/60$

Assumed that required speed is 10 cm/s i.e., 100 mm/s

$100 = \pi D N/60$

$DN = 1909.86$

By the given table below,

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WHEEL DESIGN:

Velocity, V =(πDN)/60

VELOCITY 80mm/s		VELOCITY 100mm/s		VELOCITY 120mm/s	
SPEED(N) rpm	DIA(D) mm	SPEED(N) rpm	DIA (D) mm	SPEED(N) rpm	DIA (D) mm
10	152.77	10	190.96	10	229.15
20	76.38	20	95.48	20	114.58
30	50.92	30	63.65	30	76.38
40	38.19	40	47.74	40	57.29
50	30.55	50	38.19	50	45.83
60	25.46	60	31.83	60	38.19
70	21.82	70	27.28	70	32.74
80	19.10	80	23.87	80	28.64

Fig. - 3

We have chosen 30 rpm motor the Wheel diameter is 63.6mm

So,

N = 30 rpm

D = 70 mm (approx.)

Wheel width = 25 mm (approx.)

C. *Links Design and Calculation.*

If the horizontal length of stairs is 350 mm
Then, wheelbase = horizontal length of stairs – (R_f + R_r)
R_f = radius of front wheel
R_r = radius of rear wheel

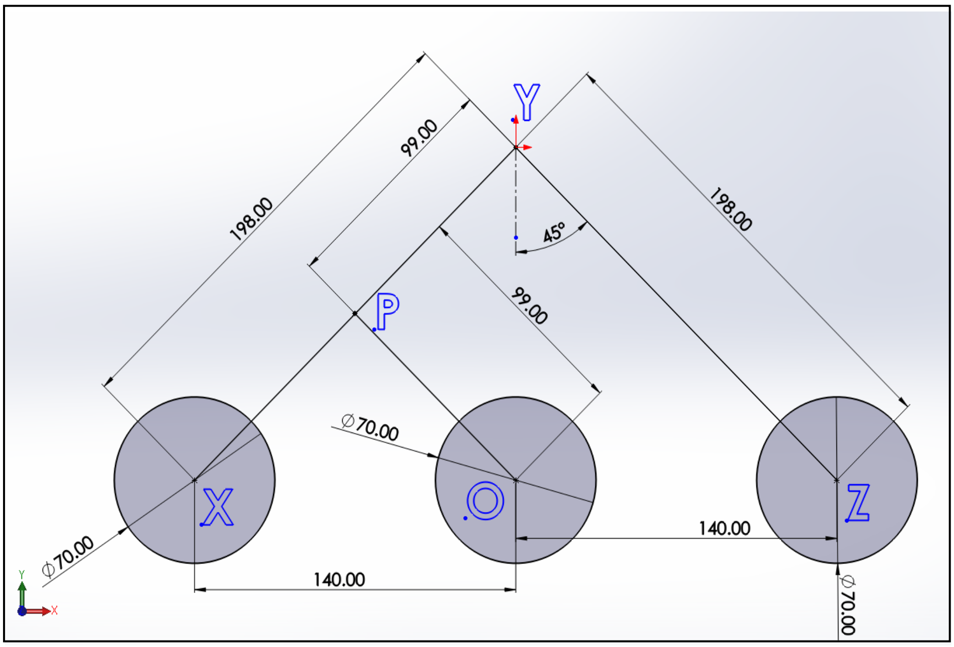

Fig. - 4

So base portion of wheel = 350 – (35+35) = 280 mm

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Let θ = 45°
In triangle YOZ, Angle YOZ = 90°
Angle OYZ = Angle OZY = 45°
So, OZ = OY
$OZ^2 + OY^2 = ZY^2$ (By Pythagoras theorem) Equation- (1)
$YZ^2 = 2(OZ^2) = 2(140^2) = 197.98$ mm
Approximate to 198 mm
Substituting in equation (1) we get,
$198^2 = 2(OZ^2)$
OZ= 140 mm
Also,
OZ = OX = 140 mm
In triangle XPO, angle XPO = 90°
$XP^2 + PO^2 = OX^2$
$2(XP^2) = OX^2$
XP = 98.99
XP= 99 mm (approx.)
We can see the symmetry so,
XP = PO = 99 mm
YP= XY – XP = 198-99
YP = 99 mm.
Height of OY
$Height^2 = YZ^2 – OZ^2$
$Height^2 = 198^2 – 140^2$
Height = 140 mm.
Net Height = Height + radius of wheel
= 140 + 35
= 175 mm.

IV. FABRICATION AND SETUP

For the fabrication of our prototype, we have made use of several features which can prove to be essential in the military. PVC pipes preferred over other materials since it is comparatively lightweight and can withstand shocks and vibrations. This can be modified and upgraded using a 3D printer according to the needs of military operations. We tried to innovate the design to improve the stability by attaching the battery LG 18650 MH1 mounted inside the legs in a perfect balance of the vehicle which greatly impacted the stability and provided long-lasting battery life making the vehicle to be ideal for long missions.

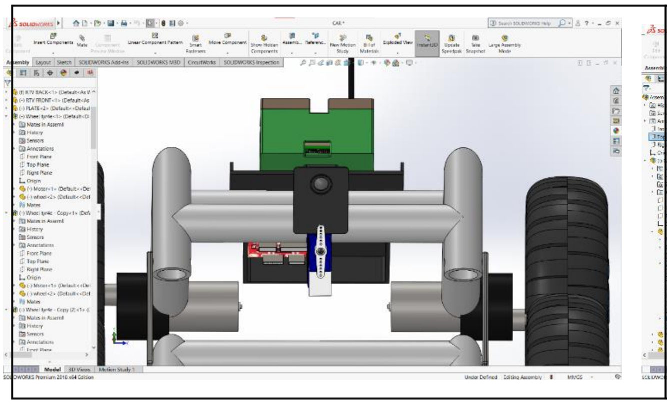

Fig. – 5

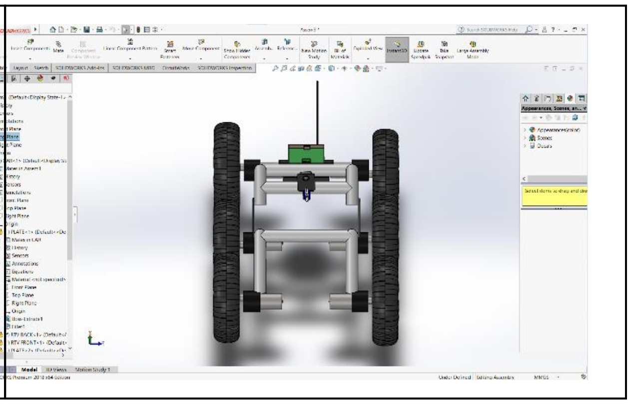

Fig. - 6

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DC gear motors were attached to each wheel individually for assisting to tackle high and uneven obstacles along the way. The SUN FOUNDER SF0180 SERVO attached with a camera-SONY IMX477R stacked, back-illuminated sensor,12.3 megapixels help it's to rotate the camera at a 360-degree angle to provide maximum coverage of areas surrounding the vehicle. PCA9685 PWM driver controls the servomotor and helps in the systematic functioning of the camera. Raspberry Pi, which is a small-sized computer is used in the vehicle to provide commands and process the functions of the prototype. The motor drivers used are TB6612 MOTOR DRIVER which provides complete control of the rough terrain-specific wheels to the operator for easy control in specific environments. A USB Wi-Fi ADAPTER is used for connectivity between the vehicle and the user to provide real-time data being captured by the vehicle. Everything used was connected with several wires, required screws, and nuts to set up everything in place. All these features can be modified according to the mission-specific needs and as the scenario requires.

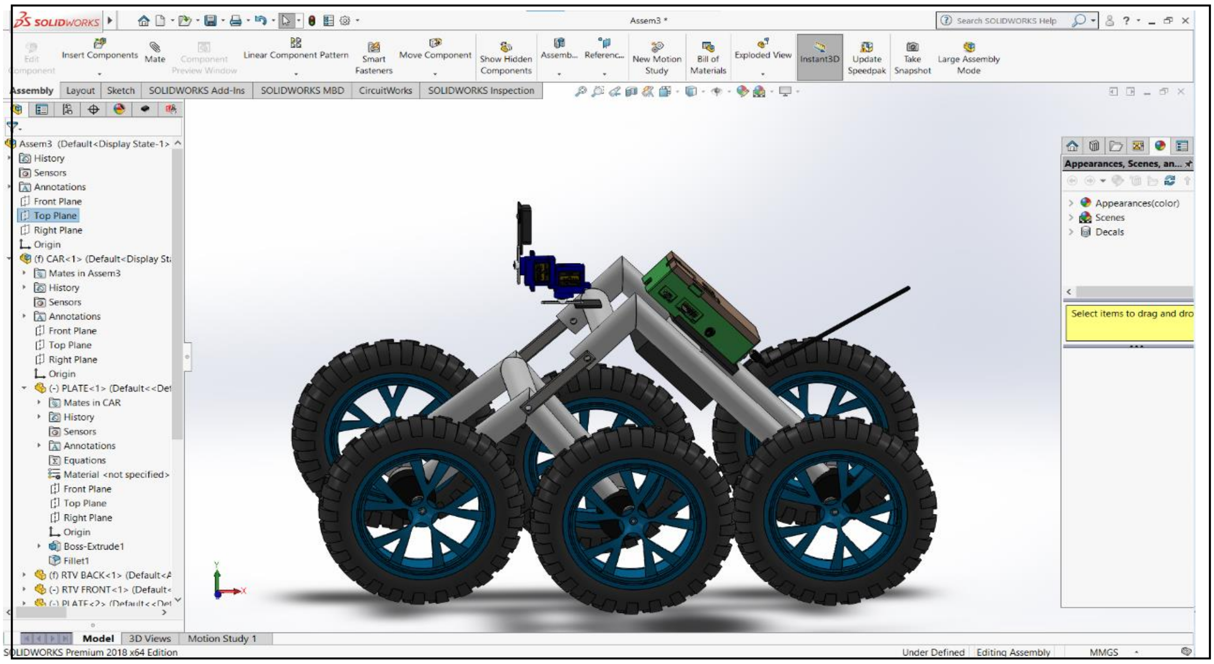

Fig. – 7

V. ROUGH TERRAIN VEHICLE VIEW

Fig. – 8

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Fig. – 9

Fig. - 10

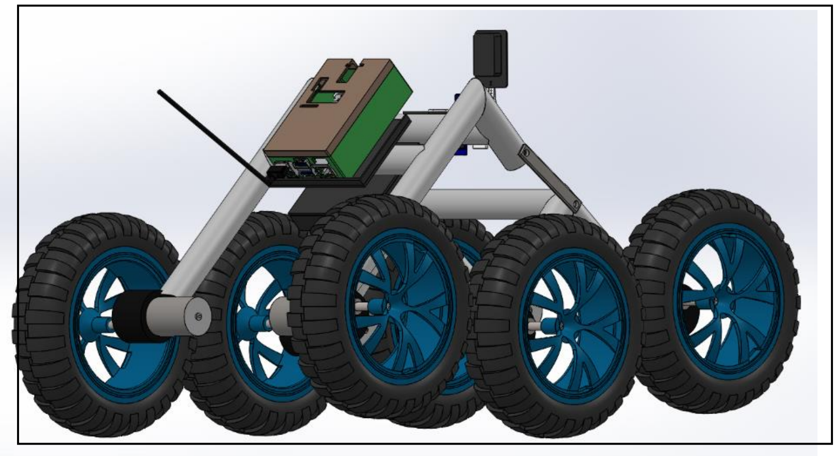

Fig. – 11

Fig. – 12

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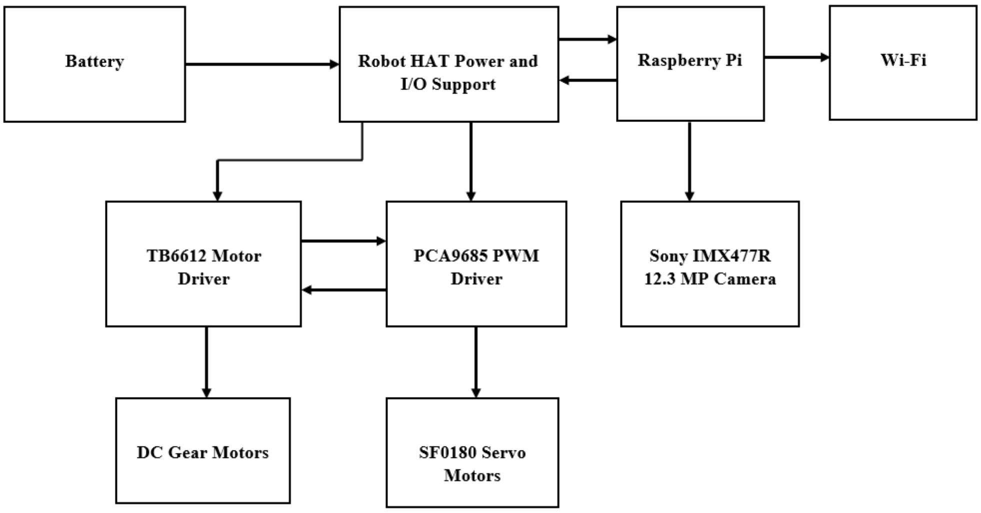
VI. WORKING PRINCIPLE

The wheels attached at the front are pushed against hurdles and obstacles by the rear wheels. The motors attached to each wheel help the wheels to grip and rotate on the rough surface. The front wheel is therefore rotated and it lifts the vehicle above the obstacle and moves forward. The middle wheel is forced by the rear wheel and pulled over by the wheel at the front causing it to lift over the rocky surface. When the rear wheel comes in contact with the hurdle, it is pulled forward by the front wheels and moved forward with the help of the motor.



Block diagram of Rough Terrain Vehicle

Fig. – 13

During this transitioning movement of the vehicle over the obstacle, the progression of the vehicle forward is very slow or almost at a pause. The slow movement helps the vehicle maintain stability while moving forward and tacking various obstacles in its path one at a time. In this prototype the pair of wheels at the front are connected to the frame with a single link connected to the mainframe and the last pair of wheels is connected directly to the frame. The connections of the wheels are attached in such a manner that will allow individuals to control in turning left and right or moving forward and backward as required. The link used at the front of the vehicle connected to the frame has 1 degree of freedom. The batteries present inside the cylindrical frame of the link provide the power to raspberry pi and therefore after receiving the signal from an individual it sends the supply to their respective components.

VII. RESULT

The main objective of this research is to use the vehicle in the military, defence, and Martian planes. We aim to adjust the dimensions of the vehicle to be able to face more harsh environmental conditions than before and the rocker-bogie mechanism was designed keeping this in mind by providing maximum stability in all terrains. The camera mounted on the rover is stable to work properly and also with an increased life span. More vibrations and jerks lead to faster wear and tear in circuit boards and cameras so we have considered this and also the battery is placed inside the links to make the placement of it at a safe location in the rover.

VIII. FUTURE SCOPE

Rough terrain vehicle can be used in exploring unknown territories, observing borders and rescue missions, as it is easy to use and it runs on Electricity. It is equipped with Wi-Fi by which individual can control movement of vehicle and direction of camera. We have fixed the battery inside the cylindrical frame of links for a long-lasting power backup. The size of the vehicle can be modified according to its requirement and the components can be upgraded as per the advancement of the technology. Apart from these we can also use different kind of sensors for different purposes. Manufacturing of different parts of this vehicle can be achieved by 3D-Printing.

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REFERENCES

[1] K. M. a. V. R. Kalamkar, Advances in Mechanical Engineering, Singapore: Springer Singapore, 2020.

[2] R. S. S., R. K. G., Y. K. A. Puneet Priyangue, “Development and Fabrication of Rough Terrain Vehicle using,” *IJESC,* vol. 10, no. 5, pp. 25696-25699, 2020.

[3] S. S. G. a. D. S. Chinchkar, “Design of Rocker Bogie Mechanism,” *IARJSET,* vol. 4, no. Special Issue 1, pp. 46-50, 2017.

[4] G. H. H. T. DINESH, “DESIGN AND FABRICATION OF ROCKER BOGIE MECHANISM,” Slideshare, Chennai, 2017.

[5] C. Y. B. S., A. G. J. M. A. S. Abhishek Verma, “Design of Rocker-Bogie Mechanism,” *International Journal of Innovative Science and Research Technology,* vol. 2, no. 5, pp. 312-338, 2017.

[6] “LG 18650 MH1 3200mAh 10A 3.7V Battery (Original),” https://robu.in/product/lg-18650-mh1-3200mah-10a-3-7v-battery-original/?gclid=Cj0KCQjwna2FBhDPARIsACAEc_Wk84oZYxigwdGzz3T-yB4M8iulqGVfcHIdkEc2Wcj3EjreDdvbHiUaAt9ZEALw_wcB.

[7] “HIGH TORQUE 12V DC GEARED MOTOR 30RPM,” https://robokits.co.in/motors/dc-geared-motors/high-torque-dc-geared-motor-30rpm.

[8] “SUN FOUNDER SF0180 SERVO MOTOR,” https://www.sunfounder.com/products/sf0180-servo-motor.

[9] “Sony IMX477R, 12.3 megapixels, Camera,” https://www.thingbits.in/products/raspberry-pi-hq-camera?utm_source=google&utm_medium=cpc&gclid=Cj0KCQjwwLKFBhDPARIsAPzPi-J3ikrMH7fPr8ZQl1sG3f_HL_hnoEKnFQHSRM1xnbAKJb31LAxai54aAj4XEALw_wcB.

[10] SunFounder, “SunFounder PiCar-V Smart Robot Video Car V2.0,” https://www.banggood.in/SunFounder-PiCar-V-Smart-Robot-Video-Car-V2_0-Kit-for-Raspberry-Pi-32B-p-1249939.html?cur_warehouse=CN&rmmds=search, 2019.