SPYDERBOT
A Robot based on Kinematic Walker Mechanism

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***Abstract*— The Field of Mechanical is now more involved in robotics, as both mechatronics and robotics are widely used in the concepts of making a robot model work with the use of servo motors as well as drives, as more energy is needed to run the robot. The Legged walkers are linked with the help of the link mechanism available. Each walker can run in the position required like forward, backward, and left and right with the help of a separate motor provided to each walker. Also, 360-degree motion can be achieved if required. This robot will integrate RGB-D and Night Vision cameras to create a rough map of the area for further inspection.**

This robot can walk slowly with a stiff gait on any surface and carries a limited load. It could be used in sewer maintenance for surveillance or any other kind of mishaps where standard wheeled mechanisms struggle to tread on. The six-legged walkers are designed and fabricated such that they can easily move on irregular surfaces. The walker legs can be stabilized with the help of active balance control to reduce instability when fast motion from the walker is required. The walker mechanism shares a spectrum of similarities from nature ranging from the physical appearance of the structure to its observed behavior.

Keywords—Kinematic Walker Mechanism, Remote Settings, Raspberry pi, Sensors, RGB-D Camera/Sensors, Night Vision Camera.

I. INTRODUCTION

This project presents a walker mechanism inspired by the living world organism, along with a command and control system that proves advantageous on varied surfaces by aiding different speeds.

For moving this mechanism via a command and control system different mechanical parts including servo motors and rods are used. This requires a frame of connecting rods, a crank, and a lever to help the structure locomote.

This mechanism incorporates links that are connected via pivot joints and helps convert the rotatory motion of the crank to a movement analogous to the movement of animal walking. Implementing a Raspberry Pi for remote control of the robot. We also presented a speed control system for a low power DC motor made with the help of a Raspberry Pi and the L293 driver. This Project includes 3D mapping using RGB-D cameras/sensors for indoor mapping of the environment along with a night vision camera for clear visibility in darker areas. The Project incorporates image processing through RANSAC & Iterative closest point algorithm (ICP) and python coding for Raspberry pi.

II. EASE OF USE

Why legged mechanism?

The Principal advantage of a non-wheeled structure or a legged mechanism is their potential to approach and access surfaces unfeasible for wheeled structures or robots. Imitating the build of a legged animal could possibly improve the performance of a remote controlled robot. To help achieve a more sturdy and stable walking mechanism scientists and engineers can take inspiration from relevant biological life forms in their designs.

The most intriguing motivation for studying robots based on the legged mechanism is:

- To help achieve access to places beyond human bounds.
- To help achieve access to places predisposed as dangerous for humans for example a radioactive zone, etc.
- To help achieve access to places that are dirty, dangerous, or having uneven terrain surfaces.
- To complete jobs rendered as difficult to complete.

Legged robots have inherent application in rescue and aiding places struck by earthquakes and in precarious places including inside of a nuclear reactor thereby, providing biologically inspired autonomous legged robots various advantages. Low power consumption and weight are crucial for walking robots, so it is of chief importance to use fewer number of actuators. To help achieve the scope of the

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project, we have to develop a six-legged mobile robot whose structure is based on the biomechanics of insects.

A. Properties Of Robot

1. It creates a 3D map of its environment.
2. It can sense its environment, and control or interact with objects in it.
3. The controller has the ability to make choices based on the environment, and use the controls to navigate the robot.
4. It incorporates Python and C++ coding making it programmable.
5. It moves with one or more axes of rotation or translation.
6. It makes dexterous coordinated movements.
7. It incorporates various sensors and cameras.
8. It has the ability to tread on uneven surfaces.

B. Abbreviations and Acronyms

1. RGB-D – Red Green Blue Camera-Depth Sensor
2. 3D Mapping – Three Dimensional Mapping
3. ICP – Iterative Closest Point Algorithm
4. RANSAC – Random Sample Consensus
5. ROS – Robot Operating System

C. Software

- Python Coding
- ROS
- RANSAC & ICP

D. Equations

1. DEGREE OF FREEDOM (DOF):

The Number of degrees of freedom of a mechanism is given by,

DOF = 3 (L – 1) – 2 J

Where,

DOF - Degree of freedom of mechanism

L - Number of links in mechanism

J - Number of binary joints in mechanism

We have, L = 7

J = 8

Hence, Degree of freedom

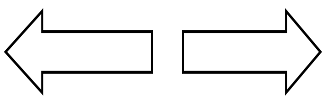
DOF = 3(7–1)–2x8

DOF = 18 – 16

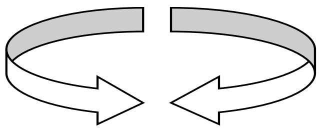
DOF = 2

The Number of degree of freedom of a mechanism is 2.

1 DOF: Left and Right motion of the Mechanism.



2 DOF: 360 Degree Rotation of the Mechanism.



2. DIMENSION FOR MECHANISM:

Part	Parameters	Dimension
Cam Link	L*B*T	30mm*15mm*3mm
Cam Shaft	L*D	48mm*5mm
Center Rod	L*D	300mm*10mm
Center Shaft	L*D	180mm*8mm
Driving Link	L*B*T	105mm*15mm*3mm
Driving Shaft	L*D	220mm*3mm
Main Leg	L*B*T	180mm*30mm*3mm
Motor Link	L*B*T	110mm*30mm*3mm
Small Shaft	L*B	30mm*5mm
Supporting Bars	L*B*T	220mm*30mm*3mm
Platform	L*B*T	190mm*150mm*5mm
Platform Support (L Section)	L*B*T	30mm*30mm*3mm
Length of Chain	L	540mm

Table 1: Dimension of Mechanism

3. CALCULATION OF GEARS:

Parameter	Formula	Calculation
Pitch Diameter (d)	d = m x z1	=1.11 x 36=40mm
Diametric Pitch (dp)	dp = z1 / d	= 36/40 = 0.9 mm-1
Outside Diameter (do)	do = (z1+2)/dp	= (36+2)/0.9 = 42.2mm
Addendum (a)	a = 1/dp	= 1/0.9= 1.08mm
Dedendum (d)	d = 1.157/dp	= 1.157/0.9 = 1.25mm
Working Depth (Wd)	Wd = 2.25m	= 2.25 x 1.11 = 2.49mm
Tooth Thickness (Tt)	Tt = 1.5708m	= 1.5708 x 1.11 = 1.7435mm

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Minimum bottom Clearance (c)	c = 0.25m	= 0.25 x 1.11 = 0.2775mm

Table 2: Calculation of Gear

III. LITERATURE REVIEW

due to its superior force-transmission angle and greater oscillating angle, compared to other types such as the four-bar mechanism, the six-bar mechanism is typically chosen for moving leg robots. due to the point of contact with the ground, force transmission is very important for leg mechanisms. the robot has two dof, one mainly for the leg mechanism itself for lifting, whilst the other for the base of the mechanism for swinging. from the full swing and lift angles, the body size and attachment dimension are determined. by entering its shape and reference coordinates, each connection is formed in the mechanism.

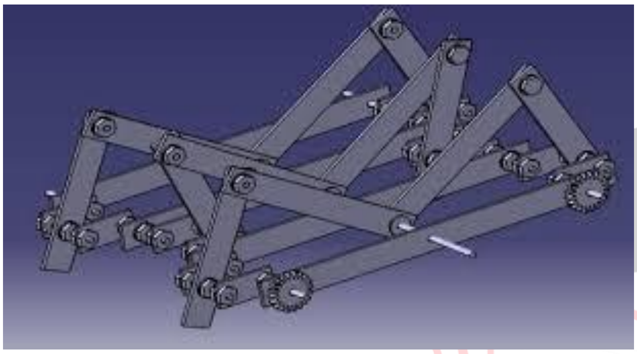

Fig 1: Kinematic Walker

A. LITERATURE SURVEY

R.Arjunraj, A.Arunkumar, R.Kalaiyarasan, B.Gokul, R.Elango Department of Mechanical Engineering Nandha Engineering College, Erode-638052, Tamilnadu, India. (2016)

In this project, a robot with six legs will be created. It is used to step over curbs, climb stairs, or fly to areas with wheels without microprocessor control and other actuator mechanisms that are currently not available.

D.Deepak1, S.Pathmasharma2 1&2 Assistant professor, Mechanical Engineering, United Institute of Technology, Coimbatore, Tamilnadu, India. (2017)

There is only front and back motion in the earlier kinematic walker. Thus it cannot be shifted or turned to the left and right motion and therefore can't be rotated. It is therefore a big disadvantage that it is not capable of moving left and right. We have planned and designed the structure in such a way that it offers operational versatility. The walker has been made more attractive and economical by this breakthrough.

Praveen1, Sumantha Raj P T2, Goravara Gadilingappa3, Kalyan Kumar S4, Dr. V. Venkata Ramana5 (2019)

The project work is successfully planned and a prototype model is made, creating a six legged kinematic walker. The goal of pushing the model on an uneven surface using the opposite locomotion gait is fulfilled. The six legged walker is designed to maneuver easily with a 360 degree rotation on uneven terrain.

DC MOTOR SPEED CONTROL WITH THE ARDUINO UNO DEVELOPMENT BOARD AND THE L293 DRIVE "Vasile Alecsandri". University of Bacau., Calea Marasesti .157, Bacau,600115, Romania (2019)

The Paper presented a speed control system for a low power DC motor made with the help of an Arduino Uno development board and the L293 driver.

An Asus_xtion_probased indoor MAPPING using a Raspberry Pi with Turtlebot Robot Turtlebot Robot, Hamza Aagela, Maha Al-Nesf, University of Huddersfield, UK (2017)

The software Gmapping issued to create a map of the surrounding area. The study makes use of the Asus xtion_ pro 3D sensor to construct an interior map utilizing SLAM and 3D representations of nearby items. The Robot generates an indoor map using the Gmapping ROS Packet in the first scenario. In the second scenario, the robot was used to produce 3D models of the room's items and the Raspberry Pi 3 was utilized to drive the robot instead of a laptop.

ABDULLAH BEYAZ AND DILARA GERDAN

The project work on vision-supported Arduino and Bluetooth-based robotic model platforms

Peter Henry, Michael Krainin, Evan Herbst, Xiaofeng Ren, and Dieter Fox (2014)

RGB-D cameras are cutting-edge sensing devices that collect RGB images as well as per-pixel depth data. We look at how such cameras can be utilized in robotics, specifically to create detailed 3D maps of indoor surroundings, in this work. In order to generate globally consistent maps, visual and depth information are merged for view-based loop closure detection, followed by posture optimization.

B. Authors and afflictions

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IV. PROBLEM DEFINITION

A. PROBLEM STATEMENT

The Current Research on the Robot is not conclusive enough to make it a viable option to replace the current technology in use. With the incorporation of smart technology including 3D mapping, long range control, and other different types of sensors and cameras that the current technology cannot hold this robot becomes a perfect viable solution.

B. OBJECTIVES

- To give access to locations having dirty, dangerous, and uneven surfaces.
- The design of these types of robots' structures contributes greatly to environmental adaptability and walking stability in dynamic and vicious non-structural environments.

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- It provides a 3D mapping of the area that is under inspection with incorporating different type of camera and sensors and a night vision camera.
- With the help of Raspberry pi and RANSAC & ICP Algorithm, the robot can be remotely driven via Laptop or remote.

C. METHODOLOGY

- The Project involves making this robot which is incorporated into the kinematic walker mechanism and controlled by remote.
- This robot can walk slowly with a stiff gait on any surface and carries a limited load. It could be used in sewer maintenance for surveillance or any other kind of mishaps where standard wheeled mechanisms struggle to tread on.
- The robot work similarly to the drone system the only difference is that it walks on the ground. This robot will integrate RGB-D and Night Vision cameras to create a rough map of the area for further inspection.
- A kinematic walker is a six-legged machine that can walk on any surface. It's a six-joint linkage system powered by a two motor.
- This mechanism resembles that of a six-legged spider. A battery can be used to power the motor. The kinematic walker consists of six legs that provide motion to move simultaneously.
- The primary benefit of legged robots is their capacity for wheeled robots to reach areas that are difficult. It may be possible to enhance the efficiency of mobile robots by copying the physical structure of legged animals. Scientists and engineers should incorporate the related biological principles in their design to provide more stable and faster walking.
- Legged robots can be employed for rescue operations after earthquakes and in dangerous environments, such as the inside of a nuclear reactor, indicating that biologically inspired autonomous legged robots have a lot of potentials. Further advantages of walking robots are low power consumption and weight, so it is necessary to use the minimum number of actuators.
- We presented a speed control system for a low power DC motor made with the help of Raspberry pi and the L293 driver. The speed of rotation of the DC motor is changed by means of a potentiometer. The speed of rotation is measured using a Hall magnetic sensor.
- The DC speed control system can also be used for the command of industrial robots. If we use Raspberry pi and two NRF24L01 shilds, we can realize the wireless remote control of the DC motor.

D. Proposed Motion of Mechanism

The Motion will be achieved by the mechanism are:

1. The Left and Right Motion will be achieved through the sprocket and chain mechanism.
2. The 360 degree rotation of the robot can be achieved by incorporating the two dc motor with the help of the L293 driver.
3. The Forward and Backward motion will be achieved by rotating the mechanism by 90 degrees and moving in forward and backward motion.

E. GAP IDENTIFICATION

- Improving the robot through remote control settings.
- Introducing 3D mapping of the robot's environment via RGB-D camera/sensor.
- Installing Night Vision Camera for a more clear view and for ease of remote access.
- Using more Water Resistant materials for less wear and tear and extending life of the robot.

F. APPLICATIONS

- Mountain transport
- 3D Map of the environment
- Disaster relief and rescue
- Military affairs
- Satellite detection
- Mineral exploitation
- Debris Searching and Rescue

G. ADVANTAGES

1. Higher Battery Life
2. Moderate Speed with aiding speed capability
3. Greater mobility on any surfaces
4. Improved frequency range for remote controlling
5. Improved isolation from terrain inconsistencies
6. 360 degree of rotation can be achieved.
7. Can be moved on any uneven surface.
8. Compact in Size

H. Figures and Tables

a) Robot 3D & 2D Model

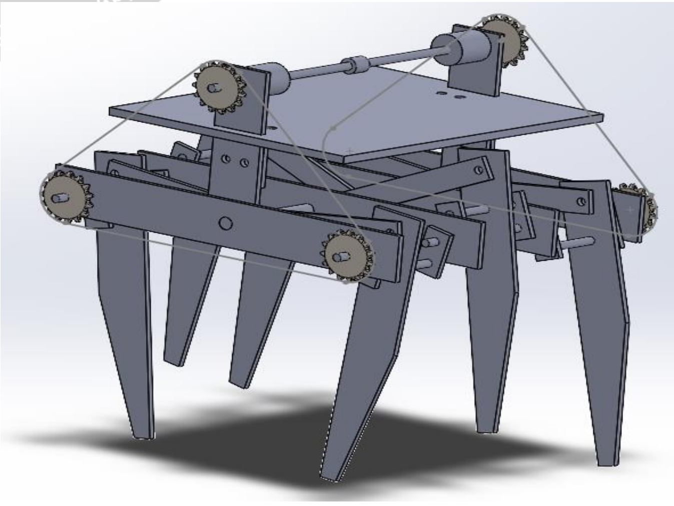

Fig 2: 3D Model

Material: Aluminum 7075T6

Mechanism Dimension: 220mm*220mm*250mm

Mechanism Weight: 2-3kg

Total Weight: 5-6kg

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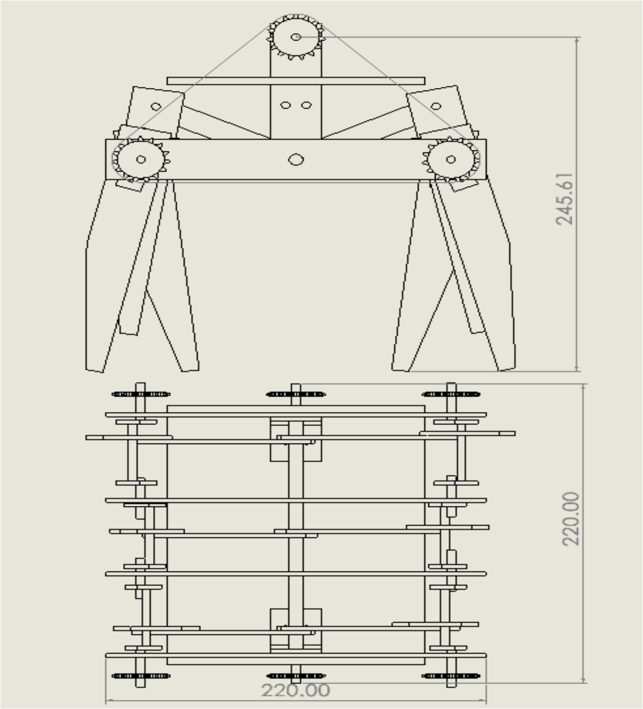

Fig 3: 2D Model

b) RGB-D CAMERA/SENSORS (Image Obtained)

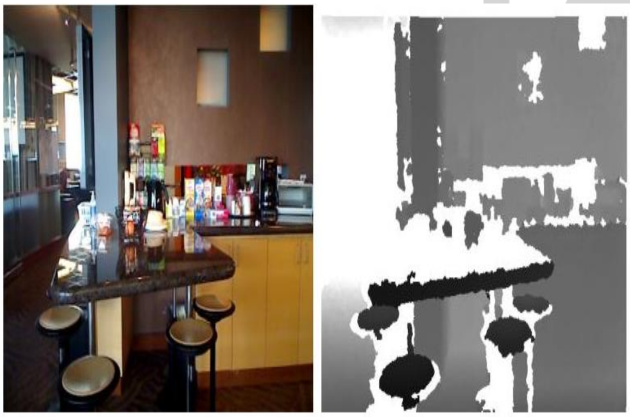

Fig 4: Image obtained from RGB-D Camera

c) Night Vision Camera (Image Obtained)

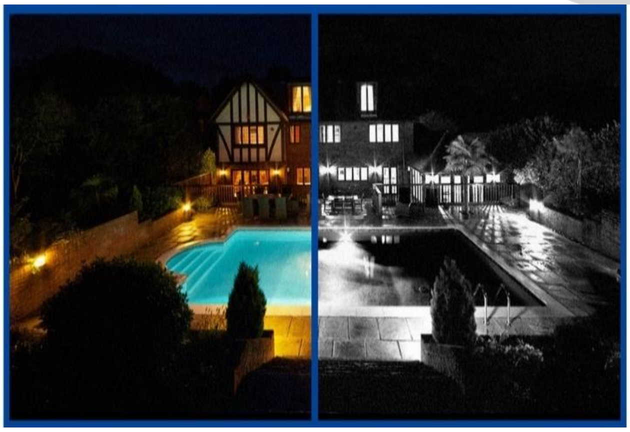

Fig 5: Image obtained from Night Vision Camera

d) Block Diagram

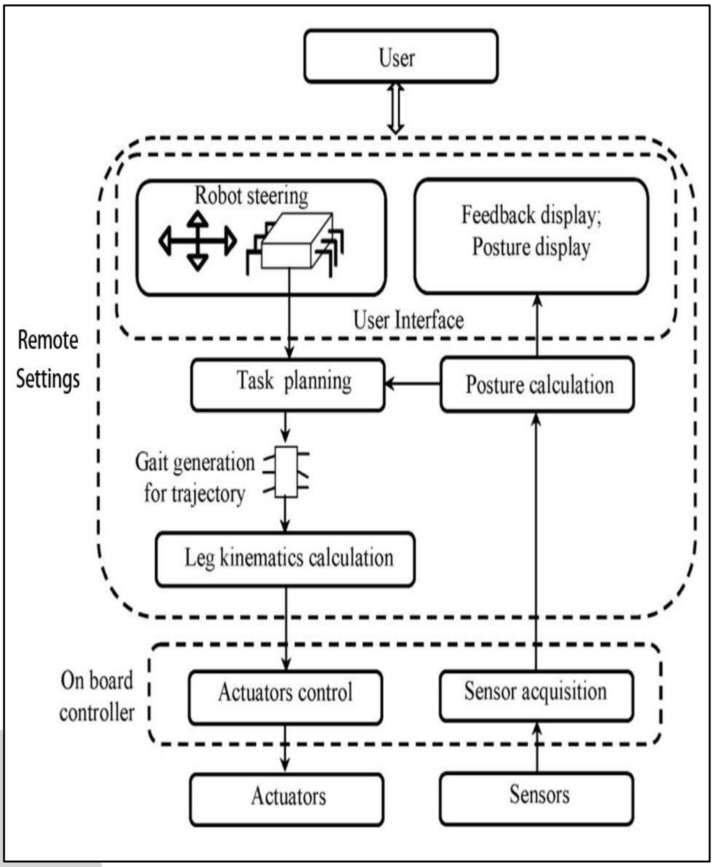

Fig 6: Block Diagram for Remote Controlling

E. COMPONENTS

1. Mechanical Components

a) Supporting Bar

The bar was designed to use bolts and nuts to link both the main legs and supporting legs. Normally, the mechanism consists of four supporting rods with sufficient gaps. The overall mechanism width is calculated by them. They serve as support for the entire connecting rod, legs, and motor arrangement. Drills are made in accordance with the position of the holes in the connecting rod and the legs at appropriate positions. To improve the ease of drilling and to decrease the weight, the thickness of these bars is generally less.

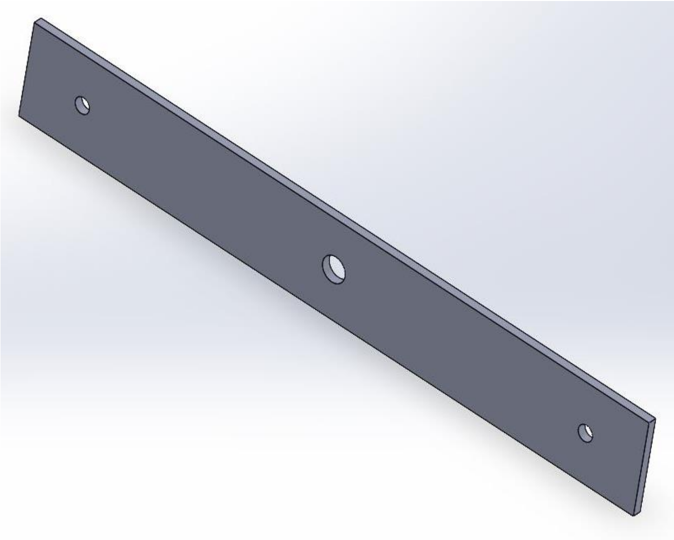

Fig 7: Supporting Bar

b) Center Rod

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The center rod was designed to screw and bolt together with the main legs and supporting legs to join the nuts and bolts.
A threaded rod is a relatively long rod that is threaded on both ends, also known as a stud; the thread can extend along the rod's full length. They are intended for use in stress. A Threaded rod is also called all-thread in bar stock shape.

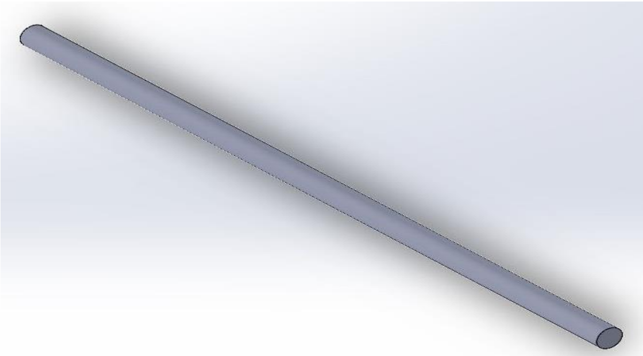

Fig 8: Center Rod

c) Main Leg
Biological systems are also influenced by legged robot locomotion mechanisms, which are very effective in moving through a broad range of harsh environments. Each leg must have at least two degrees of freedom in order to make the legged robot mobile. With the assistance of drilled holes, the main leg is paired and connected with the supporting legs. At least two degrees of freedom, one for lifting and one for swinging, are required to move a leg forward.

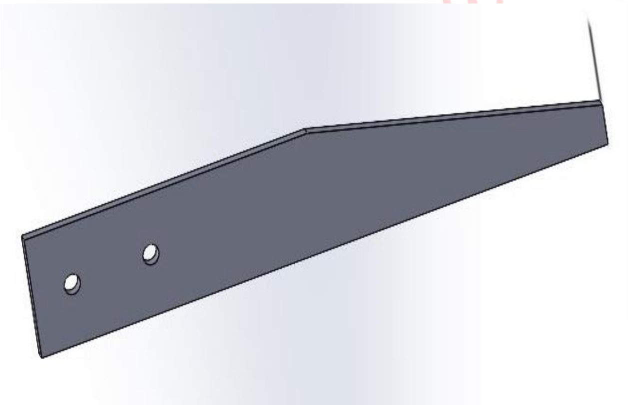

Fig 9: Main Leg

d) Supporting Leg
This supporting leg was designed to support the main legs and to provide the system with stability.

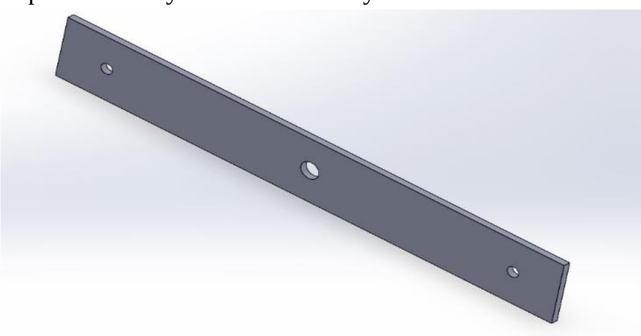

Fig 10: Supporting Leg

e) Gear and Chain
For the motion system, there are three spur gear and one chain that is meshed with all three spur gear. One of the three gears is linked to the "Driving gear" motor or engine shaft, while the other two are chain-assisted driving gear meshes. All of them work together to give the leg a spider-like walking motion.

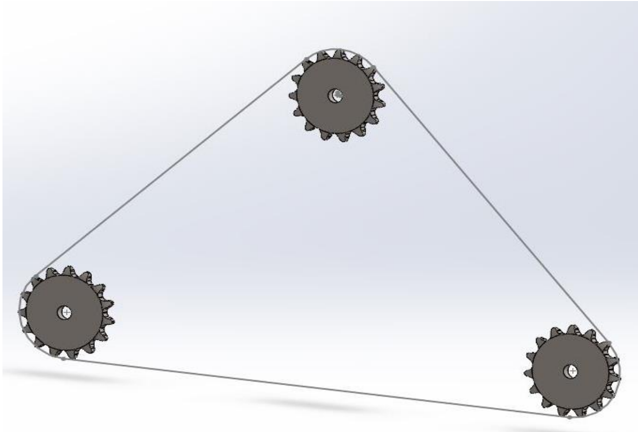

Fig 11: Gear and Chain Assembly

f) Motor Link
The Motor Link is the one in which motors are attached with the support of supporting bar, center rod & shaft. The Platform is mounted on the motor link with the help of platform support. The driving gear is attached to the center rod which passes through the motor link.

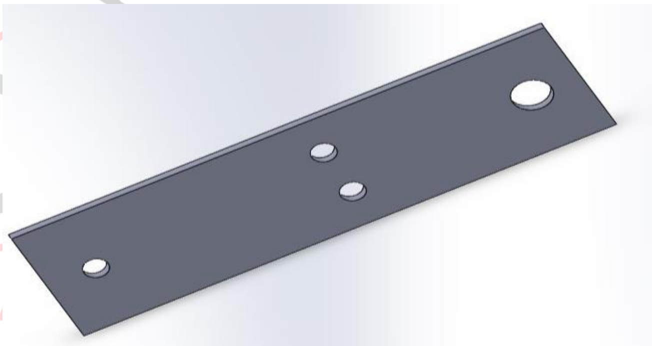

Fig 12: Motor Link

g) Platform
The Platform is mounted on the motor link with the help of the support. The various electrical components such as motor, raspberry pi, cameras, sensors, batteries, etc., and various electric connections will be carried on this platform.

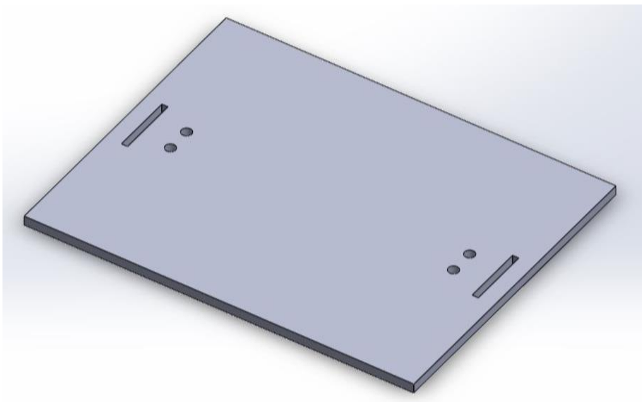

Fig 13: Platform

h) Platform Support

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It is used to hinge the platform to a particular height with respect to the motor link. It is designed as L Sections to give support to both platform and motor links. The two holes are provided on each section for connections.

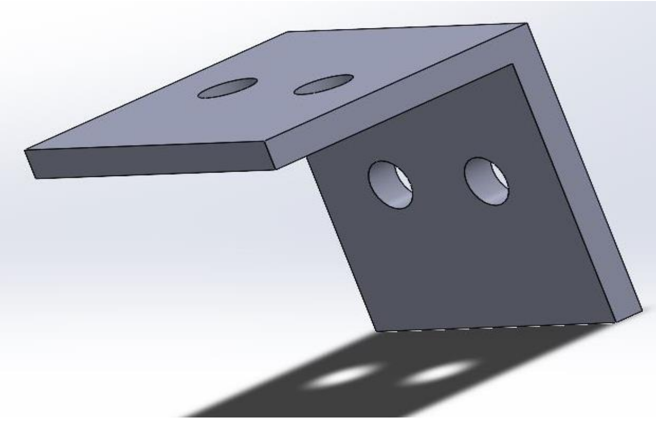

Fig 14: Platform Support

2. Electrical Components

a) Raspberry Pi

For 3d image processing via the data obtained from the RGBD & Night Vision camera. Controlling the speed of DC Motor. For remote controlling of the robot.

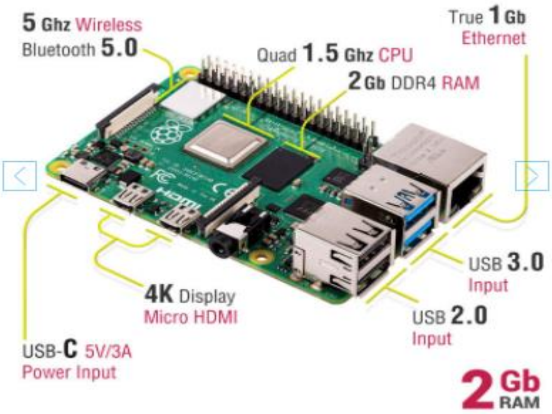

Fig 15: Raspberry Pi

b) Motor

An electric motor is an electric machine that transforms mechanical energy into electrical energy. With a motor mounted on the walker, the gear is fixed. By welding it into the walker's frame, the motor is attached to the walker. The supply is then provided to the engine for the mechanism to operate. The battery or mains can drive the engine.

Fig 16: Motor

c) NRF24L01Shilds

With the Raspberry Pi NRF24l01+ Shield Add-on for the Raspberry Pi's 32PIN Connector, you can easily connect an NRF24l01+ module and use the convenient prototyping area for connecting a variety of electronic building blocks at the same time.

Fig 17: NRF24L01Shilds

d) L293 Driver

The L293D is a 16-pin motor driver IC that is widely used. It is mostly used to drive motors, as the name implies. A single L293D IC can drive two DC motors at the same time, and the two motors' directions and speed can be regulated individually.

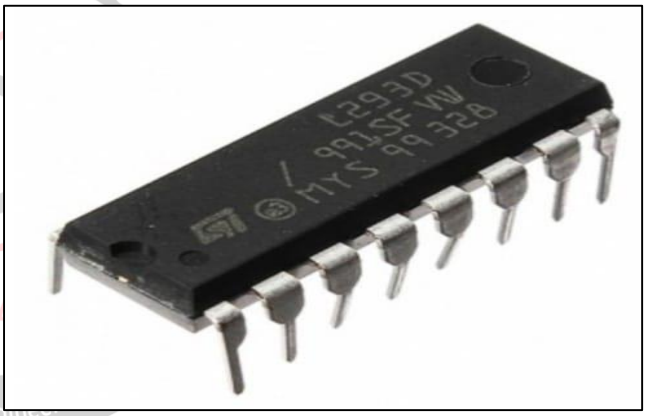

Fig 18: L293 Driver

e) Sensor

Temperature, Pressure & Humidity Sensor

Fig 19: Sensor

f) Battery (12V)

g) Remote Settings

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Via Remote Control, Laptop or Android System.

h) RGB-D Cameras/Sensors

An RGB-D image is just a fusion of an RGB image and the depth image that corresponds to it. A depth picture is a channel in which each pixel corresponds to a distance between the image plane and the RGB picture's associated object.

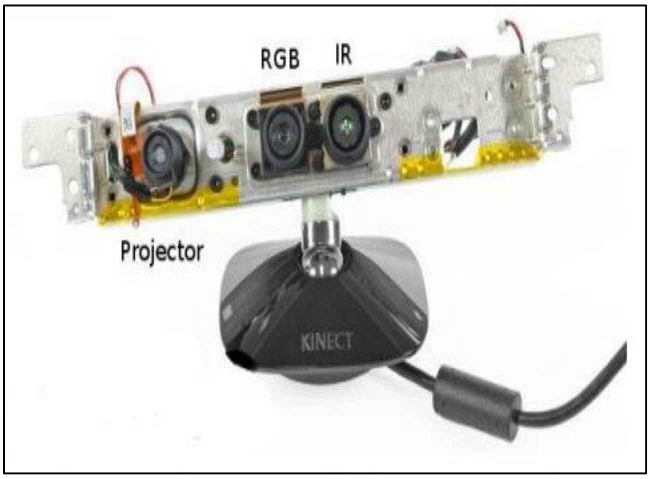

Fig 20: RGB-D Cameras/Sensors

i) Night Vision Camera

Night Vision Cameras use infrared light to illuminate images in the dark. We can't see it, but infrared light is actually all around us. The cameras detect these invisible infrared wavelengths, enabling the camera to see in the dark.

Fig 21: Night Vision Camera

V. ANALYSIS

1. Equivalent Stress on Platform

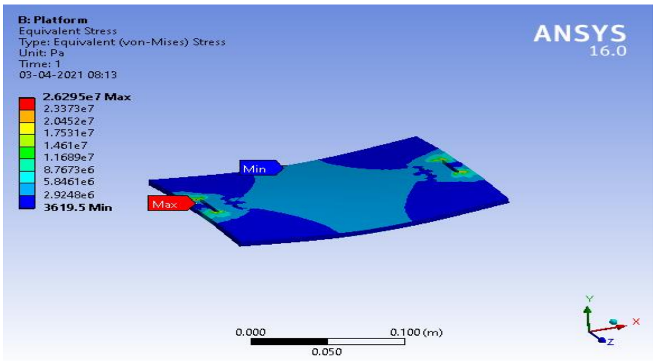

Fig 22: Stress on Platform for Load 200N

2. Equivalent Stresses on Platform Support

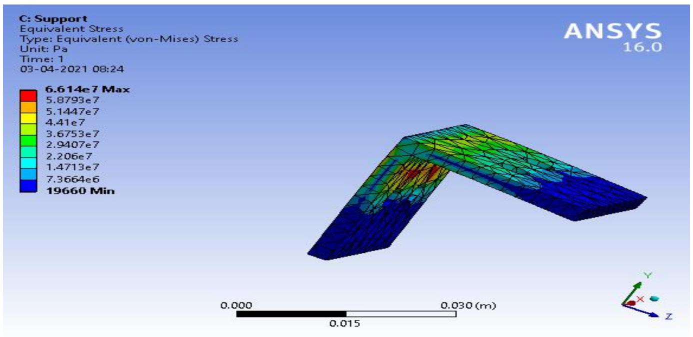

Fig 23: Stress on Platform Support for Load 200N

3. Equivalent Stresses on Gear

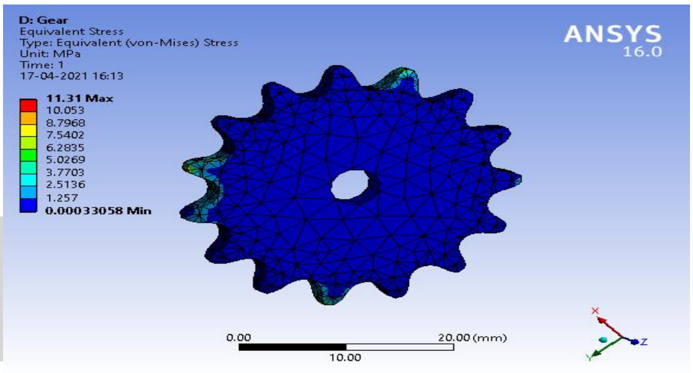

Fig 24: Stress on Gear for Torque of 120Nm

VI. WIRING DIAGRAM

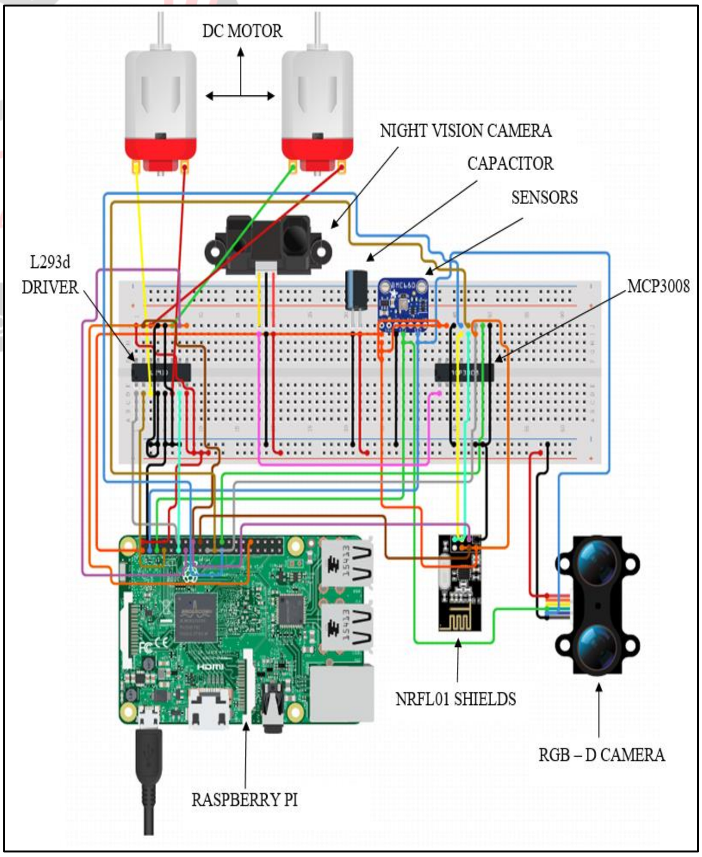

Fig 25: Wiring Diagram

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V. RESULT

The testing of a working model of the robot was decided by providing specified dimensions to the mechanism. The model was designed in SolidWorks and the prototype was fabricated with accurate dimensions of right and left motion and for controlling the movements the controller was made. We programmed the 3D mapping using C++ coding, by the successful integration of RGB-D camera/sensors. We also have taken live interface from an installed night vision cameras on the robot. We also successfully programmed the Remote Controlling of the Walker through Python Coding with the help of Raspberry Pi. The Kinematic Mechanism that was the main integration of the robot was successful for treading on uneven surfaces.

Therefore, the planned "Kinematic Robotic Walker with 360 Degree Motion with Camera" concept and produced a prototype. Since we named SPYDERBOT which is derived from two names i.e. SPYDER form Spider Mechanism another name for kinematic walker mechanism and other word BOT from Robot.

VI. OBSTACLE CLEARANCE

The main motive of constructing the SPYDERBOT was to overcome obstacles that comes within the approach wherever the wheeled robots are helpless. For example, a wheeled bot cannot pass over pebbles or even small stones on rocky terrain, and wheeled bots in the desert or sand are struck and slip. Whereas SPYDERBOT locomotion is primarily based totally on choosing and pushing mechanism and its extensive stability can easily conquer rocky and sandy terrains. Due to this aspect, SPYDERBOT can be used in defense and in military applications such as mine detection and espionage. It can be used in research and exploration in such areas where men cannot reach such as in volcanic research. This principle could also be applied to sample exploration and testing on other planets and asteroids.

VII. CONCLUSION

In this project, a SPYDERBOT is being constructed. It's used to step over curbs, climb stairs, or travel into regions with wheels that don't have microprocessor control or other actuator mechanisms that aren't available right now. On a flat, firm surface, it would be impossible to compete with the efficiency of a wheel, but as the path's roughness rises, this linkage becomes more viable, and wheels of similar size cannot handle the challenges that this linkage can. Further, pivoting arms would be used for optimization.

The remote control is used for moving the robot as well as make a 360° rotation. The RGB-D camera/Sensor helps create a 3D Map of the Robot's environment.The Night vision camera helps to guide the user in darker environments.

VIII. FUTURE SCOPE OF WORK

By using various connection lengths for the front, middle and hind legs, this process can be made more flexible.

Artificial Intelligence and IOT can be induced by introducing Sensors and vision to improve the effectiveness of this robot in the future.

The range of motion and moments available at each joint is the greatest concern as it is important for achieving stance and insect like walking.

The air system can also be introduced to use the system in both aerial and ground routes.

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