Design and fabrication of a climbing robot using Ai/ML

1. Problem Statement:

Climbing robots play a crucial role in industries such as construction, infrastructure maintenance, and search and rescue. However, developing climbing robots with high adaptability to various surfaces, efficient locomotion, and obstacle avoidance remains a challenge. Traditional approaches often lack the ability to adapt in real-time to complex environments. This research aims to address these issues by designing and fabricating a climbing robot that utilizes Artificial Intelligence and Machine Learning (AI/ML) for enhanced performance.

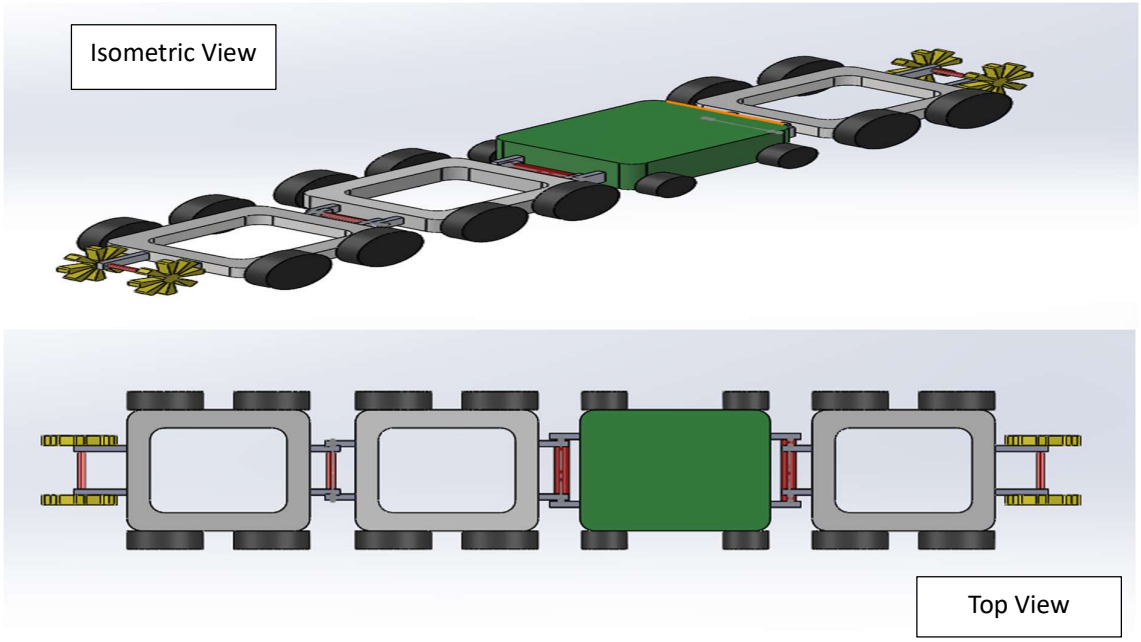
2. Methods:

Our approach involves integrating AI/ML algorithms into the design and control of a climbing robot. Key methods include:

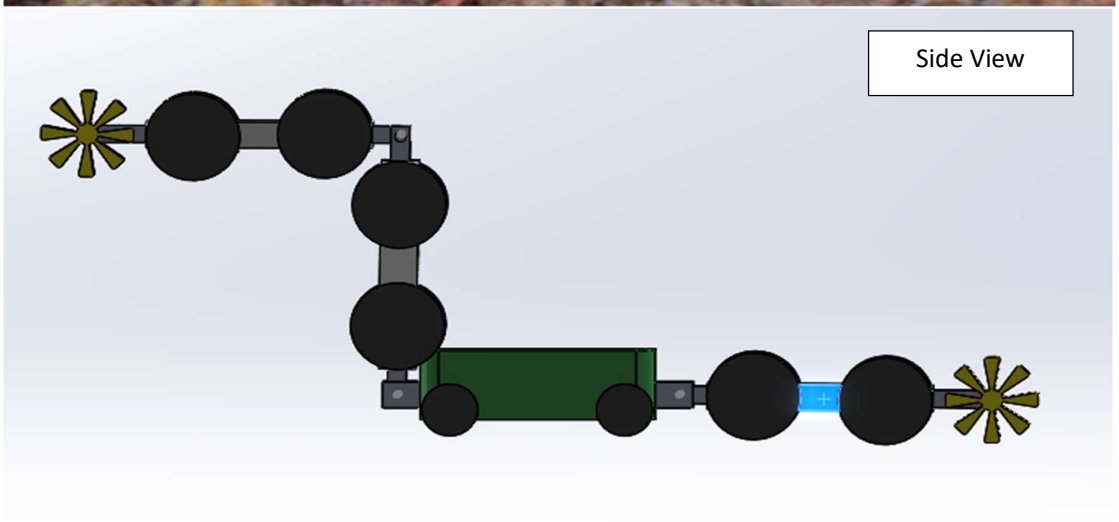
- **AI-based Vision Systems:** Implementing computer vision algorithms to perceive the environment and detect surfaces and obstacles.
- **Reinforcement Learning:** Employing reinforcement learning to enable the robot to adapt its climbing strategy based on surface conditions and obstacles.
- **Mechanical Design:** Developing a versatile climbing mechanism that can handle a variety of surfaces, including rough walls, smooth glass, and curved structures.
- **Sensor Fusion:** Integrating multiple sensors (e.g., LiDAR, cameras, tactile sensors) to provide a comprehensive understanding of the robot's surroundings.

3. Figures:

Design-



Comparison of centipede climbing with our designed robot-



Reinforcement Learning environment:

- The reinforcement learning algorithm especially Deep Q Learning can be implemented which can dynamically predict the rotation of the joints and torque of the motors connected to the wheels to enable the robot to climb stairs.
- *Rewards:* The robot can be rewarded positively for every step it climbs and the negative rewards can be imposed for impossible joint angles or stalling too much on a particular step.
- The DQN network can then be tuned in a virtual environment created using either MATLAB or ROS.

Sensors:

- The camera can be used to guide the robot towards a particular target using the models for object recognition like Yolo and Resnet.
- The infrared distance sensor placed at the head of each link can tell us the distance of the link from the ground which in turn can enable us to find out the step height.

4. Fabrication:

The design proposed above can be easily fabricated using 3D printing either using PLA or ABS plastic. The wheels can be fabricated using rubber by the process of injection moulding. The Nitrile Rubber (NBR) can be used because of its resistance to oil and chemicals.

5. Applications:

The climbing robot designed through this research has broad applications, including:

Construction: Inspection and maintenance of high-rise buildings and infrastructure.

Search and Rescue: Accessing hard-to-reach areas during disaster response.

Space Exploration: Assisting in extraterrestrial missions by navigating uneven planetary surfaces.

Manufacturing: Facilitating inspection and maintenance tasks in large industrial facilities.

6. Expected Results:

- Development of a climbing robot capable of adapting to various surfaces and environments using AI/ML.
- Improved efficiency and safety in tasks traditionally performed by humans in challenging climbing scenarios.
- Enhanced versatility and adaptability, reducing the need for specialized climbing equipment.
- Reduction in operational costs and downtime in industries requiring climbing robots.

7. References:

- Sutton, R. S., & Barto, A. G. (2018). Reinforcement Learning: An Introduction. MIT Press.
- Zhang T, Mo H. Reinforcement learning for robot research: A comprehensive review and open issues. International Journal of Advanced Robotic Systems. 2021;18(3). doi:10.1177/17298814211007305