International Research Journal of Multidisciplinary Scope (IRJMS), 2026; 7(1): 1238-1251 IRJMS

Original Article | ISSN (O): 2582-631X DOI: 10.47857/irjms.2026.v07i01.08082

Experimental Study and Simulation Design Analysis of Wall Climbing Robot Overcoming "PEEL OFF" and "ROLLOVER" Issues

Rakesh R[1]*, Joshuva Arockia Dhanraj[2], Hamsadhwani V[3], Shivakumar N[4], Ilangovan P[5]

[1]ECE, Periyar Maniammai Institute of Science and Technology, Thanjavur, Tamil Nadu, India, [2]Department of Computer Science and Engineering (AI&ML), Dayananda Sagar University, Bangalore, India, [3]Department of EEE, Periyar Maniammai Institute of Science and Technology, Thanjavur, Tamil Nadu, India, [4]Department of Mechanical Engineering, Periyar Maniammai Institute of Science and Technology, Thanjavur, Tamil Nadu, India, [5]Department of Computer Science and Engineering, Periyar Maniammai Institute of Science and Technology, Thanjavur, Tamil Nadu, India. *Corresponding Author's Email: rak2win@gmail.com

Abstract

In this growing era of technology, there is always a rising demand for usage of wall climbing robot for its various application in industries. These rise in demand has provoked the research in this area to design and fabricate an efficient wall climbing robot (WCR). Though there are many design parameters involved in determining an efficiency of wall climbing robot, the key parameters lie with its payload and self-weight that is directly linked with the adhesive mechanism which in turn is influenced by two major issues namely peel off and roll over which remains as major constraint for the practical application of the bot. In this article, the experiment is handled in two different cases. In case-I, an experimental study is enhanced to measure the payload capacity of the proposed wall climbing robot both in static and dynamic mode. The actual result obtained as an outcome of the real time experiment is compared and validated with respect to the simulation result obtained and in case-II, an experimental study is made to validate adhesive force by comparing calibrated value with experimental value and also to validate the design of introducing Smart Adhesive Mechanism (SAM) which can overlook the existing issue so called "peel off" and "roll over". A software named Edge impulse is used to collect data, create impulse and find the anomaly for the given data series through which the efficiency of the SAM is proven.

Keywords: Edge Impulse, Peel Off, Rollover, Smart Adhesive Mechanism, Static and Dynamic.

Introduction

Wall climbing Robots (WCR) have diversified areas of application. Especially these robots play major role in handling nondestructive testing in industrial environment where human life is under threat. These robots have higher impact of applications in ship building industries for performing sandblasting and water jetting process. The performance of these WCR is justified with two major design features namely payload and self-weight. The relationship between these two features is found to be directly proportional. But for an efficient WCR, it is always essential to design high payload with low self-weight robots. Keeping this as an objective, in this paper an attempt is made to design a wall climbing robot with high payload to weight ratio. The fabrication of the WCR can't be done directly without proper simulation design satisfying the objective considered. In this paper one such simulation software named CoppeliaSim is used to design the proposed model and analyze the performance of the proposed design of WCR by varying the input parameters. Finally, the simulated resulted is compared with that of the hardware testing result. Though there are many researchers working on this design of WCR with different adhesive mechanism, very few have discussed on SAM which is essential to overcome the rollover and peel off effect. The performance of the WCR both in static and dynamic condition studied in simulation mode using the software named CoppeliaSim. This simulated result validated and justified with the actual result by performing the real time experiment in this study. The wall climbing robot designed consists of four magnetic wheels FZW63 made of NdFeB material. Each magnetic wheel exerts 330 N force as per the specification given from the firm. The novelty of the work lies in

(Received 08th September 2025; Accepted 13th January 2026; Published 30th January 2026)

providing an additional adhesive force through central electromagnetic disc exerting 147 N from each electromagnet.

Hence an additional 441 N force exerted from the central electromagnet disc increase the static payload capacity of the proposed WCR which is novel when compared to the existing hybrid adhesive mechanism of WCR. In this section, a detailed review on existing wall climbing robots is made. The analyze is also made on remedy to overcome the wall climbing robot issue especially peel off and rollover effect. A design which can roll, crawl based on bioinspired robot was proposed in (1). A discussion on constraints involved in dynamic model of WCR was done (2). The recent research in the bot that can climb vertical surface was presented (3). A survey paper on advances in WCR and its challenges was done (4). A general equation of motion for mechanical system was proposed (5). The discussion on adhesive mechanism and the locomotive techniques for climbing robot was made (6). Another discussion on the design and development of pylon climbing robot with 5 degrees of freedom was presented (7). An innovative adhesive mechanism called HMA (hot melt adhesion) for climbing bot was presented (8). A compound mechanism which can walk and crawl was presented (9). A novel design of WCR to measure paint film thickness in the wind turbine was proposed (10). A wall climbing hexapod having shape memory alloy with actuated suction gripper was developed (11). A WCR to detect concrete surface flaws was introduced (12). A WCR with linkers and gears for adhesion was presented (13). A grasping claw gripper mechanism as adhesive mechanism for WCR was developed (14). T bot with two driving wheels for WCR was proposed (15). ASTERISK. With gait for limb mechanism to move on narrow spaces was presented (16). A series chain with two tracked wheel as climbing mechanism was presented (17). An hybrid adhesive mechanism for WCR in thermal power plant was developed (18). A bionic robot that works in high altitude (19). An innovative design for magnetic crawler by introducing load dispersion mechanism (20). An online impedance adaption controller which uses proportional derivative controller adjusting the peeling off angle was introduced (21). A pressing type passive suction cups and one motor was developed (22). A shape adaptive magnetic adhesive mechanism for wheeled WCR which overcomes the peel off was introduced (23). A mechanical model of spine wheel to grab the surface with multiple spines to overcome the peel off was presented (24). The force required to overcome the roll over issue was calculated (25). Kendall model of investigating the peel off force was developed (26). A rocking motion, a kind of normal force overcoming the peel off in small and agile WCR was introduced (27). The usage of Edge computing for anomaly detection to ensure safety in mining was presented (28). The dynamics of vertical climbing mobile robot. In this paper (29), an experimental study is done to determine the actual adhesive force with a comparison of its calibrated value and a novel approach is made to overcome the peel off and roll over issue with the help of SAM or central electromagnet disc. The usage of predictive analytic model from Edge impulse for reliability prediction of industrial equipment was presented (30). The Edge impulse as MLOps platform for tiny machine learning was presented (31). The current status and trends of research in wall climbing robot is discussed (32). A hybrid adhesive mechanism for wall climbing robot is discussed (33).

Methodology

The analytical equation to determine the primary objective to optimize the payload [P] value and self-weight [W] value of the proposed WCR is as given in equation [1] where α prioritize the payload capacity and β prioritize the lightweight-ed design, both are weighting factors.

$$x \min J = \alpha W - \beta P \qquad [1]$$

The proposed methodology is to design the WCR in the simulation software and then fabricating the exact hardware for the real time experimental testing. The performance of the proposed design is analyzed by comparing the result obtained from simulation and real time experiment in case -I discussed under section 3.1. Further the model is deployed for analyzing weather the proposed design is able to overcome the peel off and rollover issue.

Case-I Design Analysis -Experiment Vs Simulation

The bot is fixed at a height of 169 cm above the ground and the test is continued under four different conditions at central disc like no solenoid

excitation [0], single solenoid excitation [1], double solenoid excitation [2] and triple solenoid excitation [3].
The number of solenoids at central disc is restricted to maximum count of 3 as the theoretical calculated adhesive force value is greater than the desired adhesive force by analyzing through free body diagram. On each condition the additional weight disc is allowed to hang on trial-and-error basis and the maximum payload carrying capacity for each condition is noted from the test and is tabulated as given below (Table 1).

Table 1: Maximum Payload – Actual Result (Experimental Result) Vs Simulation Result

Condition	Height in cm	Max payload (kg) at which the peel off starts	
		Actual result	Simulation result
No solenoid excited No load condition	169 cm	12 kg	30 kg
Single solenoid excited	169 cm	34 kg	36 kg
Double solenoid	169 cm	55kg	43 kg
Triple solenoid	169cm	91 kg	50 kg

The graphical illustration of Figure 1 to Figure 5 shows that the outcome of both experimental result and simulation result exhibits same slope of gradient. The novelty of the bot with triple solenoids excited at central disc helps the WCR to carry a payload of 91 kg at static mode which is a new bench mark when compared to the existing methods. Thus, in static mode the bot exerts payload: weight ratio value of 20:1. The bot is allowed to climb a distance of 70 cm (i.e., from 104 cm to 174 cm) with varied condition from central disc like no solenoid excitation [0], single solenoid excitation [1], double solenoid excitation [2] and triple solenoid excitation [3]. On each condition the additional weight disc is allowed to hang on trial-and-error basis and the maximum payload carrying capacity for each condition is noted from the test and is tabulated as given below. The simulation result is obtained using the CoppeliaSim software as shown in Figures 6 (A-D) & 7 (A-D). There are three observations made in this dynamic mode which is as discussed below. Figures 6A, 6B, 6C and 6D depicts the simulation result under varied payload (i.e., maximum payload under each condition). The Figures 7A, 7B, 7C, 7D depicts the simulation result under fixed payload (i.e., the fixed payload considered here is 4kg). Table 1 shows the maximum payload capacity with respect to varied count of solenoid excitation in central disc both in simulation and real time experiment.

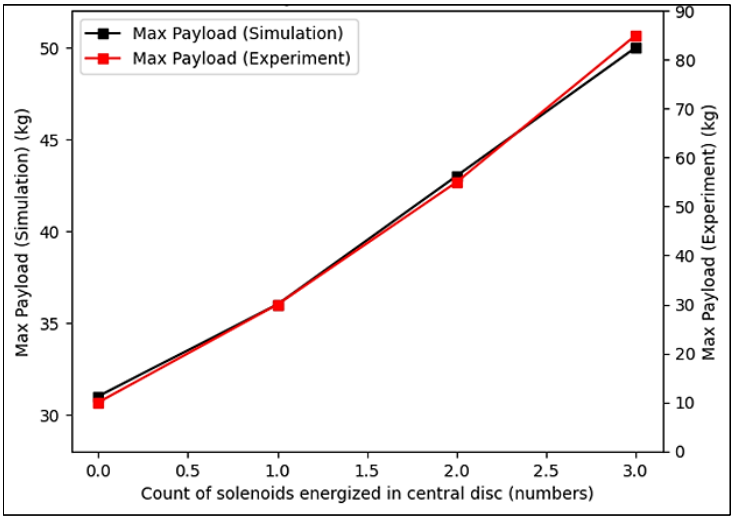


Figure 1: Static - Max Payload Vs Count of Solenoids Energized at Central Disc

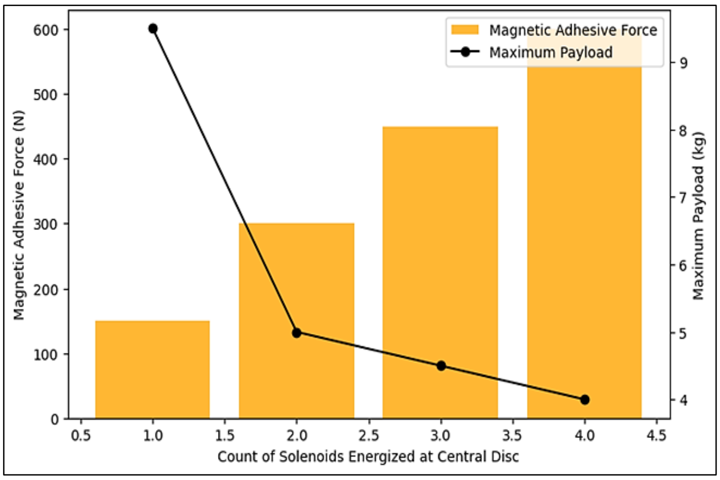


Figure 2: Static - Max Payload Vs Count of Solenoids Energized at Central Disc

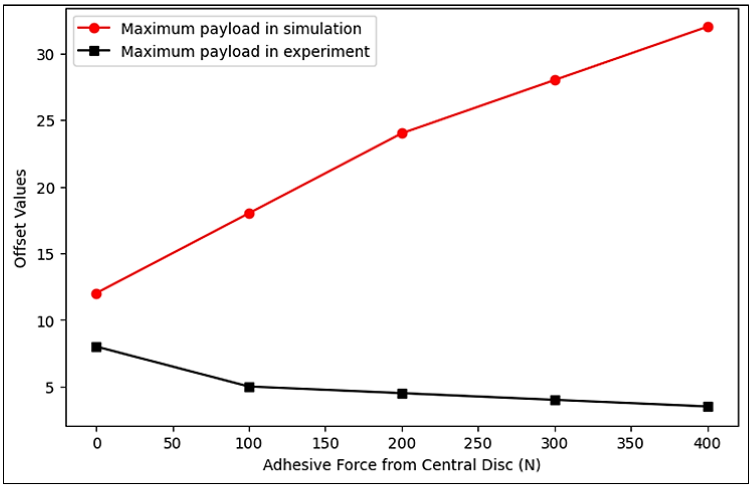


Figure 3: Maximum Payload – Actual Vs Simulation

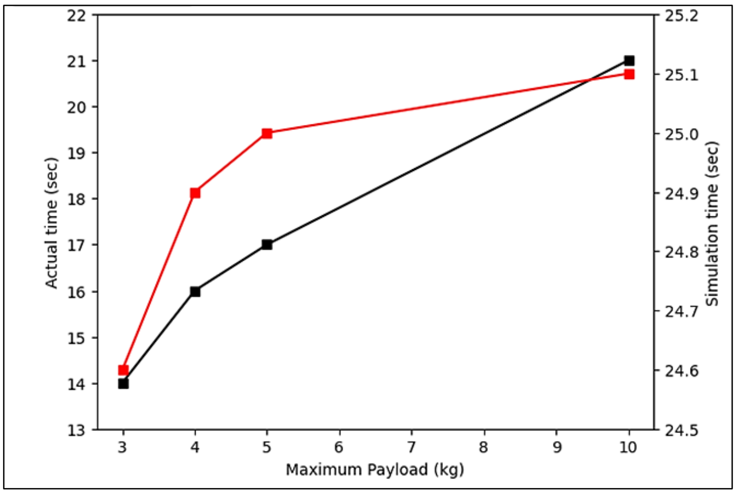


Figure 4: Varied Payload –Exp Vs Simulation Result

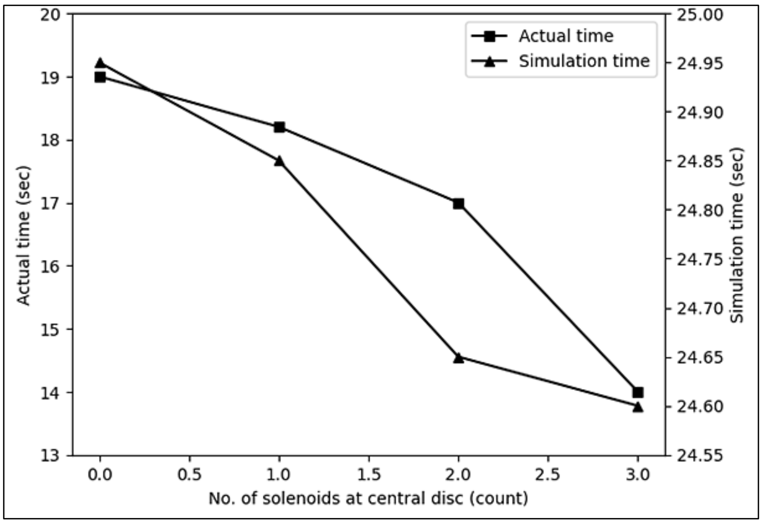


Figure 5: Fixed Payload –Exp Vs Simulation Result

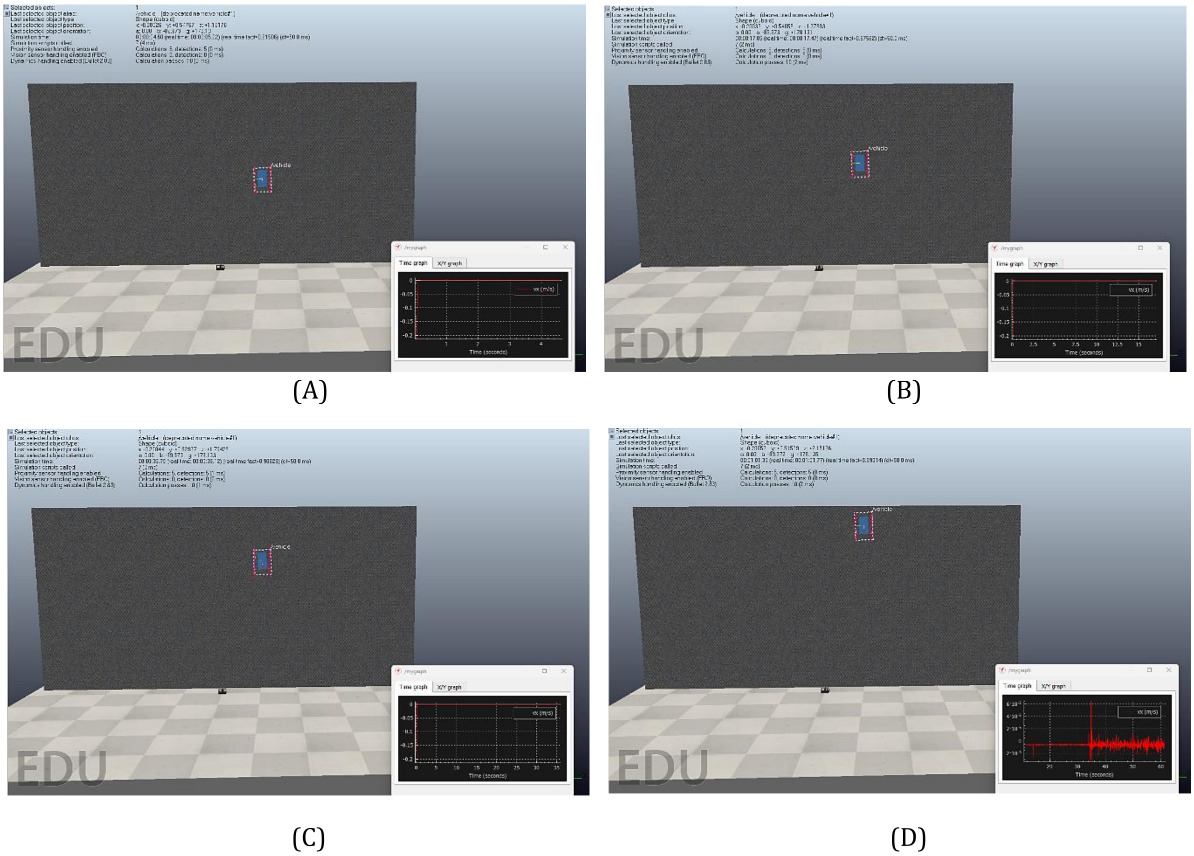
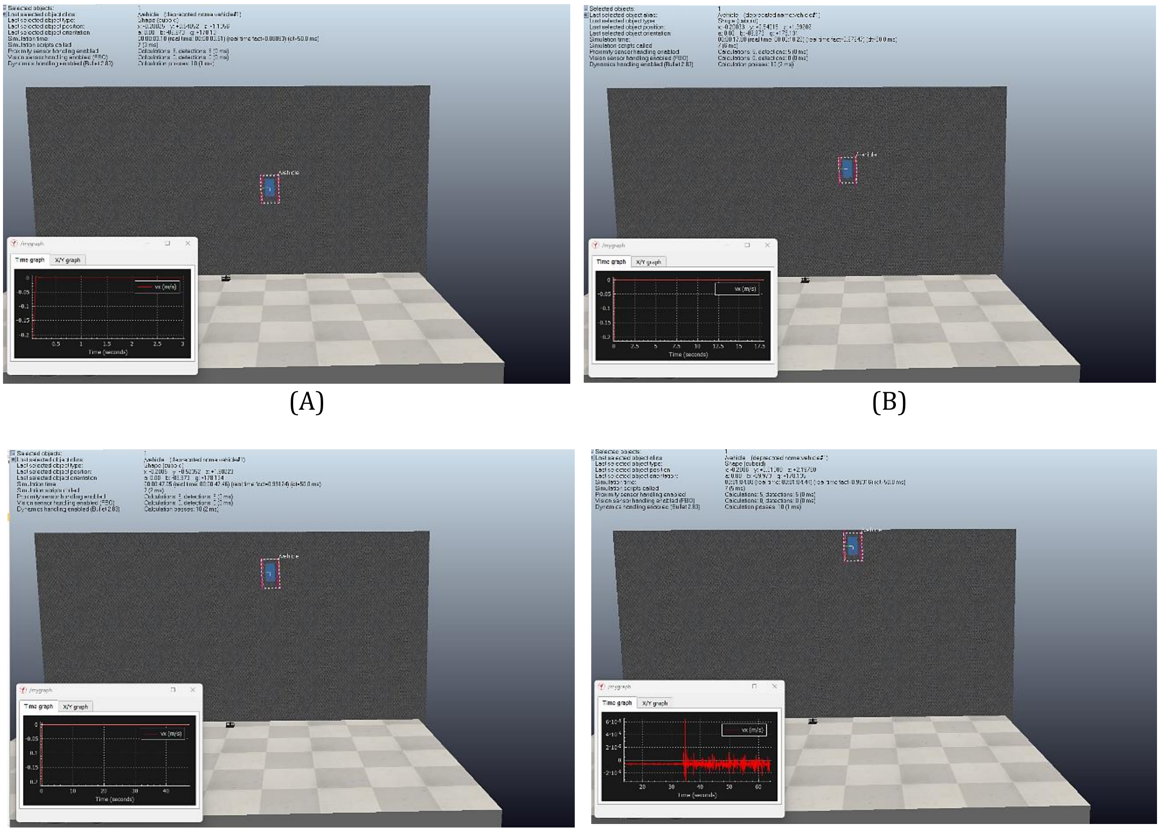


Figure 6: Simulation for Varied Payload- Dynamic Mode -(A) No Solenoid Excited at Central Electromagnetic Disc, (B) 1-Solenoid Excited at Central Electromagnetic Disc, (C) 2-Solenoid Excited at Central Electromagnetic Disc, (D) 3- Solenoid Excited at Central Electromagnetic Disc



(A) (B) (C) (D)

Figure 7: Simulation for Fixed Payload-Dynamic Mode: (A) No Solenoid Excited at Central Electromagnetic Disc, (B) - Solenoid Excited at Central Electromagnetic Disc, (C) 2- Solenoid Excited at Central Electromagnetic Disc, (D) 3- Solenoid Excited at Central Electromagnetic Disc

Table 2: Observation-I -Maximum Payload Capacity-Experimental Vs Simulation Result

Count of solenoids in Central Disc	Adhesive Force Exerted from Central Disc (Newton)	Maximum Payload in Experiment (Kg)	Simulation Result (kg)
0	0	10	56
1	147	5	62.6
2	294	4.5	71
3	441	4	76

In Observation-I, the maximum payload capacity is compared both in experimental and simulation. Table 2 shows how the adhesive force has impacted in actual experiment and also via the simulation mode. It seems maximum payload is carried only when there is no solenoid excited in actual experiment where as in simulation mode the maximum payload is carried at 3 solenoid excitations. This difference is because of the influence of magnetic friction force exerted by the electromagnet when the solenoids are excited at central disc.

In observation-II, comparing the time taken for carrying the varies payload is tested both in simulation and real time experiment. Table 3 compares the time taken for carrying the maximum payload under different condition like no solenoid (0), single solenoid (1), double solenoid (2) and triple solenoid (3). The time taken for each condition is noted from test and tabulated as given below. Similarly, the time taken under each condition is noted from the simulation result as shown in Figure 7(A-C). In both the case the bot is allowed to climb a distance of 70 cm. The graphical illustration of Figure 4 shows that the outcome of both experimental result and simulation result exhibits same slope of gradient. The graph says that as we energize a greater number of solenoids at central disc the stability of the bot is increased in dynamic static or in other words the time taken to carry the payload when three solenoids energized is less when compared to the time taken in double solenoid excitation, single solenoid excitation and no solenoid excitation. In observation-III, the time taken for carrying the fixed payload is compared both in simulation and real time experiment. Table 4 compares the time taken for carrying the fixed payload of 4 kg under different condition like no solenoid (0), single solenoid (1), double solenoid (2) and triple solenoid (3). The time taken for each condition is noted from test and tabulated as given below. Similarly, the time taken under each condition is noted from the simulation result as shown in Figure 5. In both the case the bot is allowed to climb a distance of 70 cm. The graphical illustration of Figure 5 shows that the outcome of both experimental result and simulation result exhibits same slope of gradient. The graph says that as we energize a greater number of solenoids at central disc the stability of the bot is increased in dynamic or in other words the time taken to carry the same payload (i.e., 4kg) when three solenoids energized is less when compared to the time taken in double solenoid excitation, single solenoid excitation and no solenoid excitation.

Table 3: Observation-II-Varied Payload –Experimental Vs Simulation Result

Conditions	Height to be Climbed in cm	Varied (max) Payload (kg)	Actual Time Taken in Experiments (seconds)	Simulation Time Taken (sec)
No solenoid excited No load condition	70 cm	10 kg	21 sec	25.19
Single solenoid excited	70 cm	05 kg	17 sec	25.15
Double solenoid	70 cm	4.5 kg	16 sec	24.91
Triple solenoid	70 cm	4 kg	14 sec	24.71

Table 4: Observation-III -Fixed Payload –Experimental Vs Simulation Result

Condition	Height to be climbed in cm	Actual Time taken (seconds)	Simulation Time Taken (seconds)
No solenoid excited No load condition	70 cm	19	25.01
Single solenoid excited	70 cm	18	24.96
Double solenoid	70 cm	17	24.81
Triple solenoid	70 cm	14	24.71

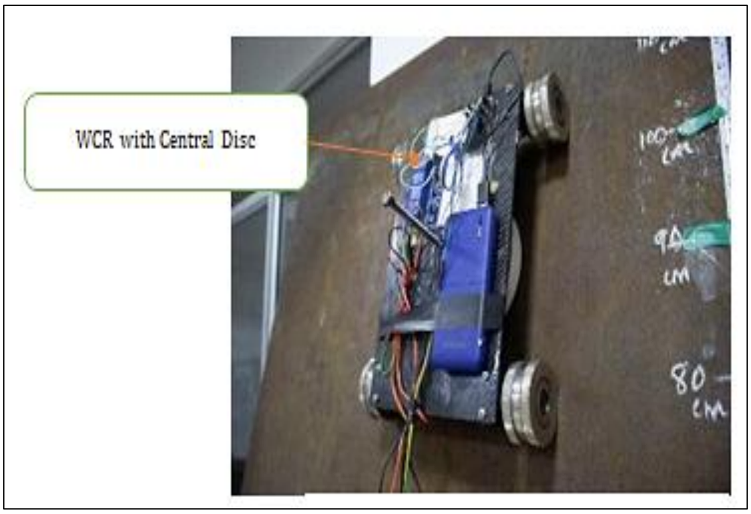


Figure 8: Side View of the Bot on Test Wall

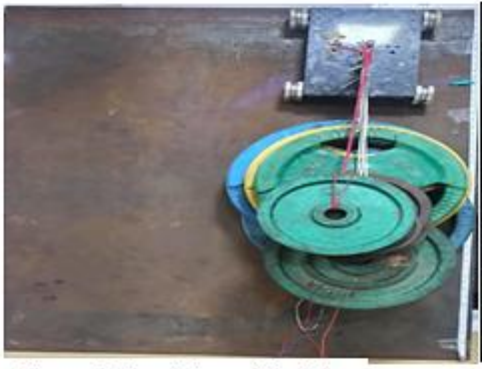


Figure 9: Front view of the Bot with 91 kg

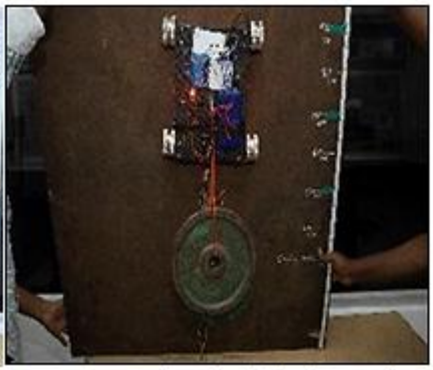


Figure 10: WCR with Payload tilted to Verify Rollover

Figure 8 shows the WCR (which weighs around 4.5kg) with central electromagnetic disc on test wall. Figure 9 shows the front view of WCR carrying a payload of 91kg. Figure 10 shows the WCR with payload tilted to verify rollover.

Case-II - Diminution of Peel off & Roll over

Here in case 2 experiment, the sensors in WCR are linked with Edge impulse software. The reference input is received when the bot is climbing in normal position. Figure 11 shows the two types of test data with active and inactive SAM. The central electromagnet gets energized automatically the input received from gyroscope sensor which tracks the tilting angle of the wall with respect to ground whenever there is sudden change in the angle of climbing, say for example if the bot is tilted to obtuse angle beyond 90^{o} to 180^{o}, as shown in Figure 12 to Figure 15, the central electromagnetic disc will get energize in order to provide an additional adhesive force by which it rectifies the roll over (i.e., the bot tilting in z axis). The central disc of the bot also gets energized when there is a peel off happening i.e. robot struggles in x and y axis which is sensed from the input received from accelerometer sensor which tracks the vertical movement of WCR on vertical wall. This happens when there is a slippery on the test bed wall or if the bot is not able to carry the payload at certain height above the ground. This feature of central electromagnetic disc makes it unique to mention as SAM. Figure 16 shows the WCR in obtuse angle of 180° and Figure 17 shows the bot in upside down inverted position with active SAM overcoming the rollover issue. Figure 18 shows the flow of control from the actual bot which is placed on test wall to the edge impulse software which takes care of collection of motion data and finding the anomaly with respect to reference data and two test data. Finally, the stability of the bot is proven with active SAM through the anomaly detection graph (Figure 19 and Figure 20).

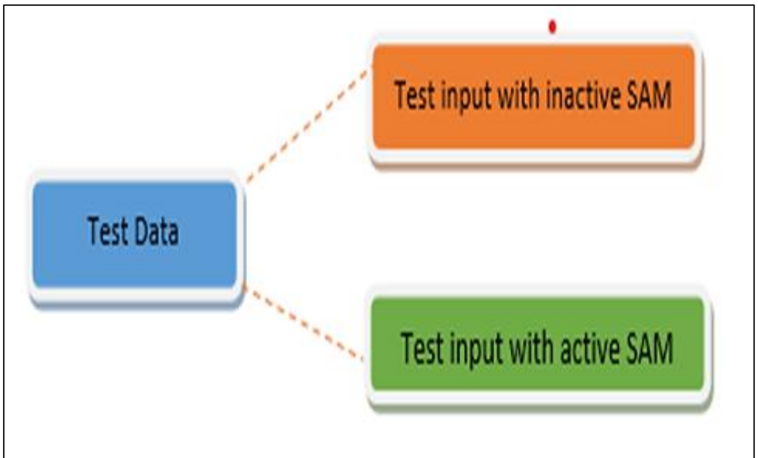


Figure 11: Types of Test Data

Figure 12: Bot at Obtuse Angle (95°) with Active SAM Carrying Overcoming Rollover

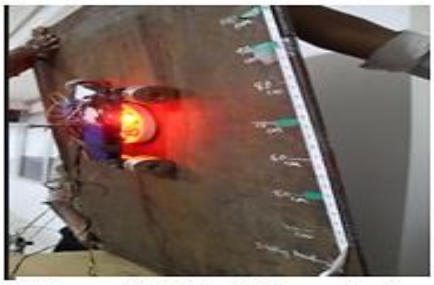


Figure 13: Bot at Obtuse Angle (100°) with Active SAM Carrying Overcoming Rollover

Figure 14: Bot at Obtuse Angle (105°) With Active SAM Carrying Overcoming Rollover

Figure 15: Bot at Obtuse Angle (120°) With Active SAM Carrying Overcoming Rollover

Figure 16: Bot at Obtuse Angle (180°) with active SAM Overcoming Rollover

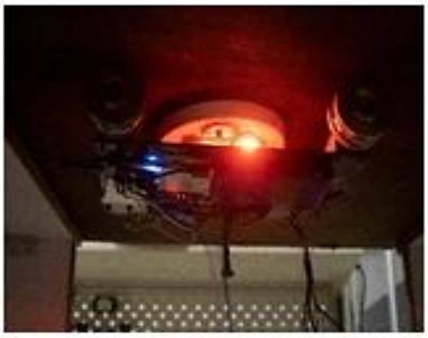


Figure 17: Bot at Upside Down Inverted with active SAM Carrying Payload of 20 Kg Overcoming Rollover

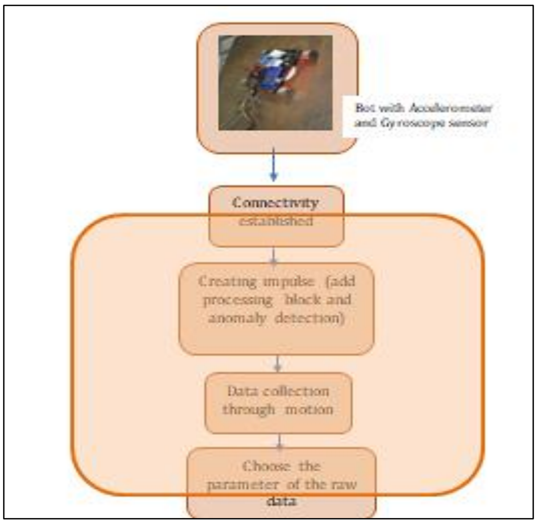


Figure 18: Block Diagram of Ana Moly Detection Process

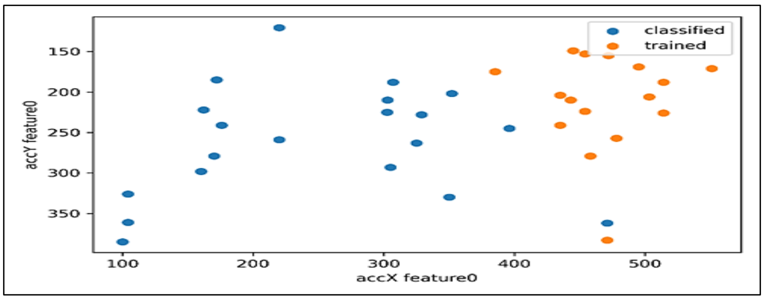


Figure 19: Bot without SAM vs Actual Reference Data

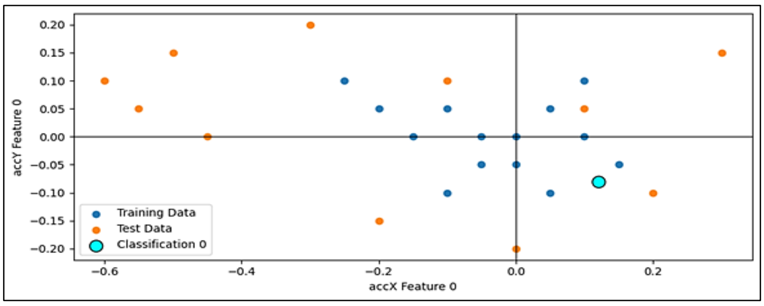


Figure 20: Bot with Active SAM vs Actual Reference Data

Results and Discussion

The experimental result shows the proposed bot has static payload of 91kg with all three solenoids excited and dynamic payload of 10 kg with no solenoids excited. From referring Table 5 and Table 6, it seems the proposed bot is found better in terms of the payload to weight ratio. And from Table 7, it shows the proposed bot is good in force to weight ratio too. Higher the force to weight ratio means more adhesive force is exerted from the designed WCR with less self-weight which directly influence on the higher P: W value too. Figure 8 shows the positioning of bot on the test wall and the dynamic state of the bot carrying a payload of 10 kg is tested, Figure 9 shows the static payload capacity of the bot carrying a payload of 91kg. The experiment was repeated for 20 trials and the precision of result is found to be very close value 1. The power consumption is inevitable in this proposed WCR in case of continues operation as solenoids at central disc consumes more energy while increasing the payload. The 50% of payload capacity both in static and dynamic state of proposed WCR would be considered as margin of safety.

Table 5: Comparison of Payload and Weight Ratio – WCR Using Magnetic or Electromagnetic Adhesive

	Parameters		
Reference	**Payload**	**Weight**	**P/W**
(34)	12 kg	2.23 kg	6
(35)	30 kg	<15 kg	2
(36)	68 kg	18 kg	3.5
(37)	10 kg	6.4 kg	1.6
(38)	40 kg	30 kg	30

Table 6: Comparison of Payload and Weight Ratio – WCR Using Magnetic or Electromagnetic Adhesive

	Parameters		
Reference	**Payload**	**Weight**	**P/W**
(39)	35 kg	14.6 kg	2.33
(40)	101 kg	80 kg	1.3
(41)	12 kg	1.2 kg	10
(42)	200 kg	20 kg	10
(43)	Mother-59 kg, Child-1.2	Mother-18, Child-0.8	3.2,1.5
Proposed WCR	Static-91kg Dynamic-10kg	4.5 kg	Static-20.2 Dynamic-2.22

Table 7: Comparison of Force to Weight Ratio - WCR Using Magnetic or Electromagnetic Adhesive

Reference	Robot Weight(kg)	Maximum Applicable Adhesive Force(N)	Force to Weight Ratio	Applicable Medium
(35)	<15	1400	93.33	Ferrous wall
(36)	18	667	37.05	Ferrous wall
(34)	2.23	121.26	54.37	Concrete wall
Proposed bot	4.5	1599	355.33	Ferrous wall

The simulation result discussed in Table (1-4) is obtained using the CoppeliaSim software. The comparison with payload: weight value (P/W) of existing WCR and how that is used to compare with proposed one as given in Table 5 and Table 6. In Simulation environment, the contact models are enabled by proximity sensor, magnetic force modelling is given via lua script, the friction coefficient and control schemes depends on the physics engine opted and here it is Bullet.

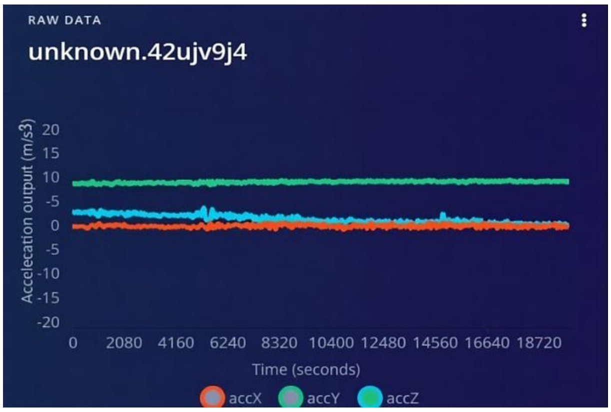


Figure 21: Reference Data

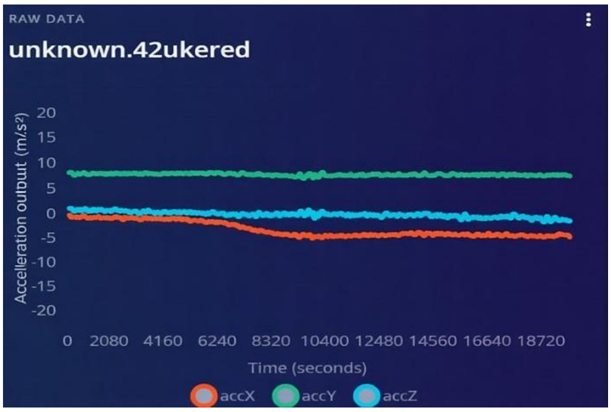


Figure 22: Data Taken with Active SAM

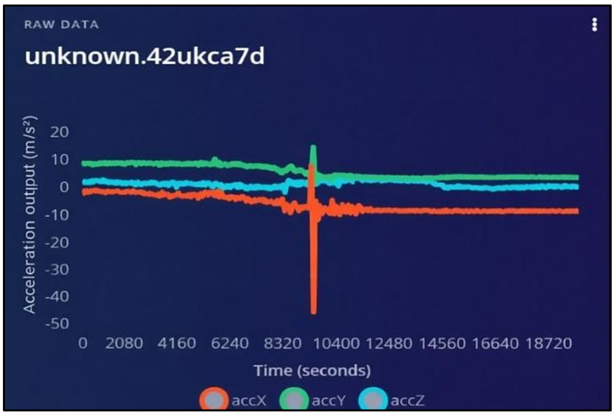


Figure 23: Data Taken with in Active SAM

Figure 21 is the graph which is considered as reference data. The data series in Figure 22 and Figure 23 are the test data input. Figure 22 is the data taken with active SAM. Figure 23 is the data taken with inactive SAM. Now with this input, anomaly detection plot is derived as shown in Figure 19 and Figure 20. The anomaly between the reference input and the test input with inactive SAM is shown in Figure 19 whereas the anomaly between the reference input and the test input with active SAM is as shown in Figure 20. Now with this input, anomaly detection plot is derived as shown in Figure 19 and Figure 20. The anomaly between the reference input and the test input with inactive SAM is shown in the Figure 19 whereas the anomaly between the reference input and the test input with active SAM is as shown in Figure 20.

Conclusion

Case-I: This payload feature of the bot makes it suitable for various industrial applications like hydro jetting, sand blasting in ship hull maintenance where static payload is more compared to the dynamic state. Even this bot (mother –child configuration) can be used in performing NDT operation in industry. The static payload capacity of mother bot can lift the child bot with payload less than 90 kg carrying all NDT equipment's and necessary power backups. The study can be further expanded in studying the impact by adding more solenoids at central disc and also by introducing a novel design overcoming the magnetic friction during the dynamic state which is considered as a constraint of the proposed one.

Case-II: Thus, through the experimental study, we have validated the actual adhesive force exerted from proposed WCR comparing it with the calibrated value. The work also helps to justify the presence of this SAM which overlooks the existing challenge "peel off" and "roll over" of the WCR. And this justification is done with the help of k means anomaly detection using IoT. This SAM in turn improvise the efficiency of the bot by providing additional adhesive mechanism whenever the abnormal situation happens during the real time application. The above experiment is conducted on casting iron wall with more surface roughness and the curvature of the wall is 0 or in other words the proposed WCR is suitable for plane wall surface with no curvature, this could be considered as a limitation of the proposed WCR. The future work to be made overcoming the above said limitation and varying the material of the metal wall. The work can be further expanded in future focusing deep on the fundamental factors like inertia, magnetic friction and traction loss.

Abbreviations

kg: kilogram, NDT: Non-Destructive Testing, SAM: Smart Adhesive Mechanism, WCR: Wall Climbing Robot.

Acknowledgement

Thanks to the open-source software Coppeliasim used for modelling and design validation of WCR through simulation. The result obtained through simulation is in line with that of the experimental result. Thanks to the edge impulse software through which the project is created for gathering the data and finding the anomaly between the reference input and two test input.

Author Contributions

Rajendran Rakesh: Concept developer, simulation, Joshuva Arockia Dhanraj: whole project, V. Hamsadhwani: literature review, N. Shiva Kumar: fabricated the hardware, P. Ilangovan: drafting the work.

Conflict of Interest

None declared.

Declaration of Artificial Intelligence (AI) Assistance

No content was taken using generative AI or AI assisted tool.

Ethics Approval

There is no specific data with required ethics approval.

Funding

No funding involved.

References

1. Yanagida T, Elara Mohan R, Pathmakumar T, Elangovan K, Iwase M. Design and implementation of a shape shifting rolling–crawling–wall-climbing robot. Applied Sciences. 2017;7(4):342. https://doi.org/10.3390/app7040342
2. Guizhi L, Peng W, Guohong L, Feng L, Shenglong D. Dynamic modeling and analysis of wheeled wall-climbing robot. Advances in Mechanical Engineering. 2023;15(6):16878132231181247. https://doi.org/10.1177/16878132231181247

3. Bogue R. Climbing robots: Recent research and emerging applications. Industrial Robot: The International Journal of Robotics Research and Application. 2019;46(6):721-7.
4. Nansai S, Mohan RE. A survey of wall climbing robots: Recent advances and challenges. Robotics. 2016;5(3):14.
5. Udwadia FE, Kalaba RE. What is the general form of the explicit equations of motion for constrained mechanical systems. J. Appl. Mech. 2002;69(3):335-9. https://doi.org/10.1115/1.1459071
6. Xiao J, Wang H. Advances in climbing robots. Contemporary Issues in Systems Science and Engineering. 2015; 3:737-66. https://doi.org/10.1002/9781119036821.ch22
7. Lu X, Zhao S, Liu X, Wang Y. Design and analysis of a climbing robot for pylon maintenance. Industrial Robot: An International Journal. 2018;45(2):206-19. https://doi.org/10.1108/IR-08-2017-0143
8. Osswald M, Iida F. Design and control of a climbing robot based on hot melt adhesion. Robotics and Autonomous Systems. 2013;61(6):616-25. https://doi.org/10.1016/j.robot.2013.02.004
9. Chen K, Kamezaki M, Katano T, Kaneko T, Azuma K, Ishida T, Seki M, Ichiryu K, Sugano S. Compound locomotion control system combining crawling and walking for multi-crawler multi-arm robot to adapt unstructured and unknown terrain. ROBOMECH journal. 2018;5(1):2. https://doi.org/10.1186/s40648-018-0099-5
10. Yang P, Zhang M, Sun L, Li X. Design and control of a crawler-type wall-climbing robot system for measuring paint film thickness of offshore wind turbine tower. Journal of Intelligent & Robotic Systems. 2022;106(2):50.
11. Sinkar A, Pandey A, Mehta C, Jayachandran S, Palani IA. Design and Development of wall climbing Hexapod Robot with SMA actuated suction gripper. Procedia computer science. 2018; 133:222-9. https://doi.org/10.1016/j.procs.2018.07.027
12. Yang L, Li B, Feng J, Yang G, Chang Y, Jiang B, Xiao J. Automated wall-climbing robot for concrete construction inspection. Journal of Field Robotics. 2023;40(1):110-29.
13. Bian S, Xu F, Wei Y, Kong D. A novel type of wall-climbing robot with a gear transmission system arm and adhere mechanism inspired by Cicada and Gecko. Applied Sciences. 2021;11(9):4137. https://doi.org/10.3390/app11094137
14. Xu F, Wang B, Shen J, Hu J, Jiang G. Design and realization of the claw gripper system of a climbing robot. Journal of Intelligent & Robotic Systems. 2018;89(3):301-17.
15. Liu Y, Sun S, Wu X, Mei T. A wheeled wall-climbing robot with bio-inspired spine mechanisms. Journal of Bionic Engineering. 2015;12(1):17-28. https://doi.org/10.1016/S1672-6529(14)60096-2
16. Ohara K, Toda T, Kamiyama K, Kojima M, Horade M, Mae Y, Arai T. Energy-efficient narrow wall climbing of six-legged robot. ROBOMECH Journal. 2018;5(1): 26.
17. Kim H, Kim D, Yang H, Lee K, Seo K, Chang D, Kim J. Development of a wall-climbing robot using a tracked wheel mechanism. Journal of mechanical science and technology. 2008 ;22(8):1490-8. https://doi.org/10.1007/s12206-008-0413-x
18. Jiang Z, Chen B, Ju Z, Li Y, Xu Y, Zhao Y. Design and analysis of a wall-climbing robot for water wall inspection of thermal power plants. Journal of Field Robotics. 2023;40(5):1003-13.
19. Fang Y, Wang S, Bi Q, Cui D, Yan C. Design and technical development of wall-climbing robots: A review. Journal of Bionic Engineering. 2022;19(4): 877-901.
20. Hu J, Han X, Tao Y, Feng S. A magnetic crawler wall-climbing robot with capacity of high payload on the convex surface. Robotics and Autonomous Systems. 2022; 148:103907.
21. Wang B, Xiong X, Duan J, Wang Z, Dai Z. Compliant detachment of wall-climbing robot unaffected by adhesion state. Applied Sciences. 2021;11(13):5860.
22. Ge D, Tang Y, Ma S, Matsuno T, Ren C. A pressing attachment approach for a wall-climbing robot utilizing passive suction cups. Robotics. 2020;9(2): 26. https://doi.org/10.3390/robotics9020026
23. Eto H, Asada HH. Development of a wheeled wall-climbing robot with a shape-adaptive magnetic adhesion mechanism. International Conference on Robotics and Automation (ICRA). 2020; 9329-9335. https:10.1109/ICRA40945.2020.9196919
24. Liu J, Xu L, Chen S, Xu H, Cheng G, Xu J. Development of a bio-inspired wall-climbing robot composed of spine wheels, adhesive belts and eddy suction cup. Robotica. 2021;39(1):3-22. https://doi.org/10.1017/S026357471900184X
25. Liu J, Xu L, Xu J, Liu L, Cheng G, Chen S, Xu H, Shi J, Liang X. Analysis and optimization of the wall-climbing robot with an adsorption system and adhesive belts. International Journal of Advanced Robotic Systems. 2020;17(3):1729881420926409.
26. Wang H, Yamamoto A. Peel force of electrostatic adhesion in crawler-type electrostatic climbing robots. Journal of the Japan Society of Applied Electromagnetics and Mechanics. 2015;23(3):498-503.
27. Kute C, Murphy MP, Mengüç Y, Sitti M. Adhesion recovery and passive peeling in a wall climbing robot using adhesives. International Conference on Robotics and Automation. 2010; pp. 2797-2802. https:doi.org/ 10.1109/ROBOT.2010.5509142
28. Liu C, Su X, Li C. Edge computing for data anomaly detection of multi-sensors in underground mining. Electronics. 2021;10(3):302. https://doi.org/10.3390/electronics10030302
29. Serebrennyi VV, Lapin DV, Mokaeva AA. Experimental studies of the dynamics of a mobile robot with a vertical movement mechanism on magnetic caterpillar movers. Journal of Machinery Manufacture and Reliability. 2020;49(4):329-34.
30. Mihigo IN, Zennaro M, Uwitonze A, Rwigema J, Rovai M. On-device iot-based predictive maintenance analytics model: Comparing tinylstm and tinymodel from edge impulse. Sensors. 2022;22(14):5174.
31. Gookyi DA, Wulnye FA, Wilson M, Danquah P, Danso SA, Gariba AA. Enabling intelligence on the edge: Leveraging edge impulse to deploy multiple deep learning models on edge devices for tomato leaf disease detection. AgriEngineering. 2024; 6(4): 3563 -85. https://doi.org/10.3390/agriengineering6040203

32. Lou S, Wei Z, Guo J, Ding Y, Liu J, Song A. Current status and trends of wall-climbing robots research. Machines. 2025;13(6):521. https://doi.org/10.3390/s22145174
33. Zulkifli R, Husain AR, Ibrahim IS, Mazni M, Fauzan NH. Analysis of the hybrid adhesion mechanism of the wall climbing robot. In Control, Instrumentation and Mechatronics: Theory and Practice.2022; pp. 155-169. https://doi.org/10.1007/978-981-19-3923-5_14
34. Howlader MO, Sattar TP. Finite element analysis based optimization of magnetic adhesion module for concrete wall climbing robot. International Journal of Advanced Computer Science and Applications. 2015;6(8):8-18. https://doi.org/ 10.14569/IJACSA.2015.060802
35. Shang J, Bridge B, Sattar T, Mondal S, Brenner A. Development of a climbing robot for inspection of long weld lines. Industrial Robot: An International Journal. 2008;35(3):217-23. https://doi.org/10.1108/01439910810868534
36. Kalra LP, Gu J, Meng M. A wall climbing robot for oil tank inspection. International Conference on Robotics and Biomimetics 2006; 1523-1528. https://doi.org/10.1109/ROBIO.2006.340155
37. Lee G, Wu G, Kim J, Seo T. High-payload climbing and transitioning by compliant locomotion with magnetic adhesion. Robotics and Autonomous Systems. 2012;60(10):1308-16. https://doi.org/10.1016/j.robot.2012.06.003
38. Gao X, Xu D, Wang Y, Pan H, Shen W. Multifunctional robot to maintain boiler water-cooling tubes. Robotica. 2009;27(6):941-8. https://doi.org/10.1017/S0263574709005360
39. Xu Z, Ma P. A wall-climbing robot for labelling scale of oil tank's volume. Robotica. 2002;20(2):209-12. https://doi.org/10.1017/S0263574701003964
40. Souto D, Faiña A, Deibe A, Lopez-Peña F, Duro RJ. A robot for the unsupervised grit-blasting of ship hulls. International Journal of Advanced Robotic Systems. 2012;9(3):82. https://doi.org/ 10.5772/50847
41. Tavakoli M, Marques L, de Almeida AT. Omniclimber: An omnidirectional light weight climbing robot with flexibility to adapt to non-flat surfaces. International Conference on Intelligent Robots and Systems 2012; pp. 280-285. https://doi.org/10.1109/IROS.2012.6385454
42. Fei Y, Zhao X, Wan J. Motion analysis of a modular inspection robot with magnetic wheels. Intelligent Control and Automation. 2006;2:8187-8190. https://doi.org/10.1109/WCICA.2006.1713570
43. Fischer W, Tâche F, Siegwart R. Inspection system for very thin and fragile surfaces, based on a pair of wall climbing robots with magnetic wheels. International Conference on Intelligent Robots and Systems. 2007; 1216-1221. https:// doi.org/10.1109/IROS.2007.4399060

How to Cite: Rajendran R, Dhanraj JA, Hamsadhwani V, Shivakumar N, Ilangovan P. Design Analysis of Wall Climbing Robot with Diminution of “PEEL OFF” and “ROLLOVER” Issues. Int Res J Multidiscip Scope. 2026; 7(1): 1238-1251. DOI: 10.47857/irjms.2026.v07i01.08082