Comparative analysis of structural design of hexapod robot with respect to its payload to weight ratio

Yazhisai Palanivel[1], *Suvathi* Sasikumar[1],*Parkavi*Senthilkumar[1],*Rakesh*Rajendran[2]

[1-]UG Students, Department of Electronics and Communication Engineering, Periyar Maniammai Institute of Science & Technology (Deemed to be University), Vallam, Thanjavur 613403,Tamilnadu, India
[2]Director, Centre for Excellence in Training and Research in Automation Technology (CETAT),Periyar Maniammai Institute of Science & Technology (Deemed to be University), Vallam, Thanjavur 613403, Tamil Nadu, India.

Abstract. The recent trends in the field of Robotics have evolved a lot irrespective of its application across any field. That too when wall climbing robots are considered, many researchers have come up with many innovative designs considering environmental constraints. These wall climbing robots have many industrial applications. The two major design constraints of any wall climbing robot would be this payload and self-weight of the robot. A wall climbing robot with high payload with low self-weight would be preferable for better efficient application. Though there are many designs available, the most effective and inspiring design would be the bio-inspired hexapod robots shaped wall climbing robots. Hexapod robots mean robot having six legs for its locomotion. Many researchers have proposed their own design with their own way of actuation method, stability factor and trajectory planning method. Some researchers have used software simulation tool like MATLAB, Solid Works, CATIA etc., instead of hardware modelling. In order to propose an innovative hexapod robot's wall climbing robots design, it is essential to understand the existing design proposed by various researchers particularly on this design of hexapod robots in this article, a comparison is made by visualizing these proposed models and their unique design for hexapod robots. A deep survey is made on the existing design of hexapod robot's wall climbing robot and hexapod robots with respect to its payload (p) and self-weight (w) capacity. The article also enables to understand the maximum PWR value achieved so far with this existing design of hexapod robot.

*CorrespondingAuthor:rak2win@gmail.com.

1 Introduction

Inspired by the stability and adaptability of arthropods, hexapod robots-six-legged locomotion platforms-have emerged as a major area of study in mobile robotics. They can be used for everything from industrial inspection and load-carrying missions to planetary exploration and search-and-rescue operations due to their intrinsic statically stable gait patterns, high terrain flexibility, and fault-tolerant leg configurations. However, achieving these capabilities necessitates paying close attention to the robot's dynamic behaviour under various load circumstances, actuation method, and mechanical construction. The robots self-weight and payload capacity are important performance elements that determine total mobility, energy efficiency, structural integrity, and control robustness. Designers must make progressively difficult trade-offs as hexapod robots systems continue to advance toward more autonomy and more challenging operating situations. Lightweight design is crucial for effective movement, yet high structural rigidity is required to withstand payloads. Similar to this, higher payload requirements would call for stronger actuators, which would increase the system's energy and self-weight. These interactions emphasize the necessity of thorough design approaches that combine a thorough assessment of loading conditions with structural analysis, material selection, actuator design, kinematics and dynamics modelling, and gait optimization. Bio mimetic leg structures, compliant mechanisms, multi-objective optimization strategies, and sophisticated simulation tools for load-dependent performance evaluation are just a few of the approaches to these problems that have been addressed in recent research. Nevertheless, there is still a lack of a systematic knowledge of how self-weight and payload affects design choices in the kinematic, control, and mechanical domains. This review aims to highlight trends and gaps in current techniques, identify important design parameters impacted by weight and load concerns, and compile current research findings.

2 Background

By providing a structured analysis of hexapod robot’s design strategies with emphasis on self-weight payload interactions, this review aims to support researchers and engineers in developing more efficient, robust, and application-tailored legged robotic systems. The table 1 shows the parameter category with sub parameters in the design of hexapod robots influencing the self-weight and payload capacity of hexapod robots. The various design constraints involved in hexapod robot is listed in Figure 1.

Table 1. Design parameters influencing Self-weight and Payload of Hexapod robots

Parameter Category	Sub-Parameters	Influence of Self-Weight	Influence of Payload
Mechanical Structure	Link length, cross-section, material	Heavier frame increases structural stress; may require thicker links	Requires reinforcement, increases bending loads and joint torque
Actuation System	Motor torque, gearing, power consumption	Higher weight → larger motors → weight cascade	Full-load conditions define peak torque and actuator sizing
Gait and Locomotion	Tripod/Quadruped gait, stance geometry	High weight reduces stability margin	Payload shifts centre of mass and increases risk of slip
Energy Consumption	Joint power, overall efficiency	Self-weight dominates baseline energy	Load increases mechanical work per step
Control Algorithms	Force control, compliance, load compensation	Requires gravity compensation	Requires dynamic load adaptation and disturbance rejection
Foot–Ground Interaction	Contact forces, friction, foot design	Higher normal forces increase slip risk	Payload amplifies peak ground reaction forces

2.1 Design Assumption

Generally, the hexapod robots wall climbing robots having various design assumptions like operational environmental assumptions, mechanical structural assumptions, adhesion mechanism assumptions (vacuum suction based adhesive, magnetic adhesion, gecko – inspired and dry adhesion), locomotion and stability adhesion, force and load assumption, actuation assumption, control system assumption, energy and power assumption, safety assumption etc. Boundary conditions and loading scenarios specify how a hexapod robots wall-climbing robot engages with the wall and where forces are applied to the structure. Predicting stresses, deformation, and failure locations requires these. Foot-wall contact constraints, body constraints, joint boundary assumptions are the boundary condition for a legged wall climbing robot. Self-weight (primary load case), worst case tripod support, extended leg, adhesion force loading, dynamic walking loading, payload etc.

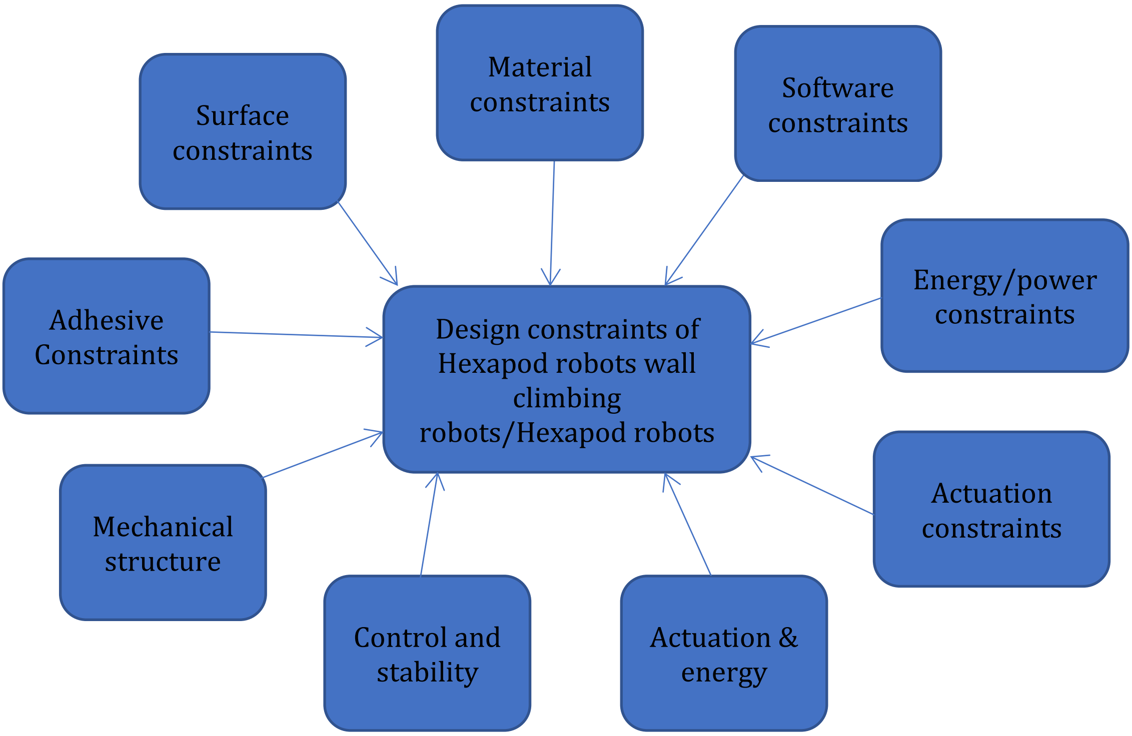


Fig.1. Design Constraints influencing the Hexapod robots

3 Problem statement

Hexapod robots are commonly employed in tasks such as inspection, search-and-rescue missions, and wall-climbing, where the ability to carry loads is essential. Although many studies have suggested various structural designs, materials, and mechanical configurations for hexapod robots, the performance metrics reported in the literature often differ widely. Specifically, the payload capacity is frequently reported without a standardized comparison to the robot's own weight.

The payload-to-weight ratio (PWR) is a crucial performance indicator that reflects structural efficiency and mechanical optimization. However, existing studies primarily focus on locomotion control, gait stability, or adhesion mechanisms, with limited systematic evaluation of how structural design choices influence payload efficiency. Furthermore, there is no consolidated review that comparatively analyses structural design strategies of hexapod robots specifically from the perspective of payload-to-weight ratio.

This lack of structured comparison makes it difficult to identify optimal design approaches and engineering trade-offs between lightweight construction and structural strength. Therefore, a systematic review following PRISMA guidelines is required to critically analyse and compare structural design methodologies with respect to payload performance.

4 Research gap

The wall climbing robots (including hexapod robots type wall climbing robot) have many design parameters out of which payload and weight forms the major design constraints. Though there is lots of research which has emphasized on structural design of the hexapod robots but very few focused on the payload and weight of the proposed hexapod robots. Hence, there is a need for a review study on these hexapod robots wall-climbing robots with respect to payload-to-weight ratio, which will enable researchers to understand the design benchmarks of such robots and to innovate new designs that overcome existing benchmark values.

5 Objectives

This review's goals are to critically analyse and contrast current hexapod robots structural designs, with a focus on payload-to-weight ratio, identify critical structural parameters that affect load-carrying efficiency, evaluate optimization strategies, and suggest future research avenues for enhancing structural performance and lightweight design.

6 Methodology

6.1 Review Protocol

The review protocol includes choosing selective research question, search strategy, inclusion criteria, exclusion criteria avoiding selective reporting, bias in study selection and data manipulation.

6.1.1 Review Question

Thought this review can be presented by answering the following questions, how do different structural design approaches in hexapod robots influence their payload-to-weight ratio? What structural configurations (centralized, modular, bio-inspired) yield higher payload-to-weight ratios? Is there a trade-off between lightweight design and structural strength? What structural optimization techniques improve payload performance? The payload to weight ratio of different structural design approaches of hexapod robots alone is considered as the review question for this article study.

6.2 Search strategy

The recent article from 2010 to 2025 is considered across various database like Scopus, IEEEexplore, web of Science which includes robot type, structural design, payload metrics

6.2.1 Inclusion Criteria:

The inclusion criteria include robot type (hexapod robot -physical prototype or experimental validated model), total weight of the robot and maximum payload capacity of the robot. Finding the PWR (payload to weight ratio value). The weight or payload of certain hexapod robots is missing; the article is included with picture of the hexapod robots which gives the structural idea of the bot. In others words insufficient technical data with respect to payload and weight is also included.

6.2.2 Exclusion criteria:

The robot mismatch like (biped or quadruped legged robot, swarm robots without structural payload.no structural focus, structural design information like (frame, chassis structure, material used, leg configuration).

6.3 PRISMA flow diagram

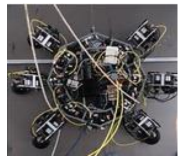
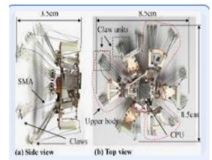
PRISMA Stage	Description	Number of Records (n)
Identification	Records identified from Scopus	45
	Records identified from IEEE Explore	11
	Records identified from Web of Science	20
	Additional records from other sources	nil
	Total records identified	80
	Duplicate records removed	35
	Records after duplicates removed	45
Screening	Records screened (Title and Abstract)	45
	Records excluded	nil
Eligibility	Full-text articles assessed for eligibility	45
	Full-text articles excluded	nil
Included	Studies included in qualitative synthesis	36
	Studies included in quantitative synthesis (if meta-analysis performed)	09

7 Structural Design classification

7.1 Literature review

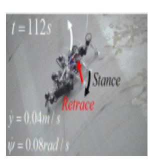
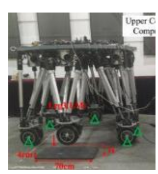
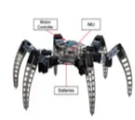
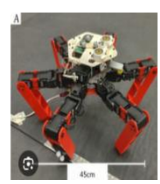
Ausama et al [1] proposed a field programmable gate array employed as controller through which each leg is actuated with one processor, this bot weighing around 548 gram is able to climb the vertical wall with bio-inspired dry adhesive mechanism as shown in Fig 14. The PWR value of this bot cannot be predicted as the payload value of this bot is not available. Bin He et al [2] proposed a hexapod robots wall climbing mechanism as shown in Fig 3, having 6-SRRR or 3 SRRR parallel mechanism weighing 5.5 kg and has the payload capacity of 2 kg. The PWR value of this bot is 0.36. Mayo et al [3] proposed a compact wall climbing hexapod robot as shown in Fig 4, having a dimension of 8.5cm and self-weight of 65 grams with payload capacity of 200 gram climbs the wall with clawed legged mechanical adhesive mechanism. The PWR value of this bot is 3.07.

Table 2. Literature review 1

Author	Ding et al[12]	Bin He et al[2]	Mayo et al[3]
Figures			
Fig number	2	3	4
Self-weight	28kg	5.5 kg	65 grams
Payload	10kg	2 kg	200 gram
PWR	0.36	0.36	3.07

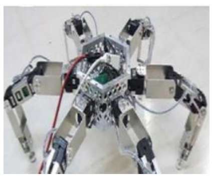
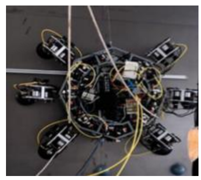
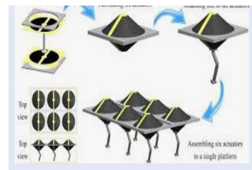
Gong et al [4] proposed a hexapod robot as shown in Fig 5 which can transverse between the angle 30 degree to 270 degrees. The payload capacity of this bot is 2 kg and the self-weight of this proposed bot is 5.2 kg. L Fan et al [5] proposed curvature climbing hexapod robot as shown in Fig 6, having under actuated legs which can climb in Omni directional way over the curvature with 2.8-16.3-meter diameter. The self-weight of this bot is 5.6 legs and the payload capacity of the bot is 2 kg. The PWR value of this bot is 0.36. Chuntai et al [6] employed the spinor theory for analysing the dof of this hexapod robot as shown in Fig 17. By means of deriving motion constraints and evaluating matrix rank to overcome the limits of G-K formula. Sun et al [7] came up with a shape changing transformable hexapod robots as shown in Fig 21, that has both legged wheeled locomotive mechanism enhanced with ladder function for climbing. It has hook model for the versatile movements.

Table 3. Literature review 2

Author	Gong et al [4]	L Fan et al [5]	Zhihua Chen [15]	Zhong et al [23]	Ilya Brodoline [19]
Figures					
Fig number	5	6	7	8	9
Self-weight	5.2 kg	5.6 kg	250 kg	10kg	3 kg
Payload	2 kg	2 kg	200 kg	8 kg	2 kg
PWR	0.38	0.36	0.8	0.8	0.66

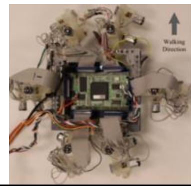
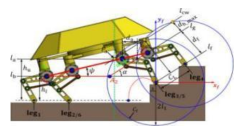
Hongfan et al [8] designed a hexapod robots as shown in Fig 10, which comprises of TGWPO and AMPSO focusing on small wall obstacle handling gait mechanism with STM32F103 based controller. Heming Hu et al [9] proposed a hexapod robots wall climbing robot as shown in Fig 11, with D-H method where tipping conditions are detected and tested with help of simulation and real time testing. Ngyun et al [10] has proposed an insect inspired printable hexapod robots as shown in Fig 12 with multiple degrees of freedom.

Table 4. Literature review 3

Author	Hongfan et al [8]	Heming Hu et al [9]	Ngyun et al [10]
Figures			
Fig number	10	11	12
Self-weight	-	-	-
Payload	-	-	-
PWR	-	-	-

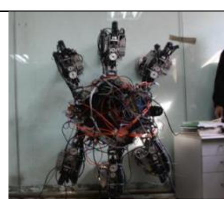
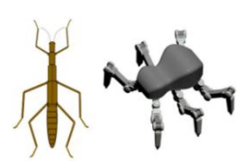
Junying Wei et al [11] employed adaptive sliding model for tracking the trajectory path of each leg in hexapod robots as shown in Fig 13. Ding et al [12] designed a hybrid hexapod robots as shown in Fig 2, which can swim in deep ocean and walk for seashore locomotion. This bot weighs 28 kg and has the payload capacity of 10kg.The PWR value of this bot is 0.36...HuayangLi et al [13] proposed a hexapod robots as shown in Fig 15, that can crawl the slope in underwater and climb the staircase inclined between 35 degrees to 45 degrees. Yue Zhao et al [14] proposed a method for hexapod robots as shown in Fig 16, to overcome the obstacle and plan adaptive motion to the complex environment which enhances the locomotion stability and kinematic feasibility

Table 5. Literature review 4

Author	Junying Wei et al [11]	Ausama et al [1]	Huayang Li et al [13]
Figures			
Fig number	13	14	15
Self-weight	-	548 gram	-
Payload	-	-	-
PWR	-	-	-

Zhihua Chen et al [15] designed a hexapod robots as shown in Fig 7, weighing 250 kg and has payload capacity of 200kg, a walking strategy for its stability was presented for BIT-NAZA -II hexapod robots which comprises of multi sensor feedback, impedance based compliance control and Beizer curve trajectory motion planning to prevent slippage.The PWR value of this bot is 0.8. He Zhang et al [16] introduced HITCR-II hexapod robots as shown in Fig 18, consisting of optimized structure to overcome navigation of unstructured terrain with the help of posture control strategy. Mena et al [17] developed a hexapod robots as shown in Fig 19, with SCARA legs that navigates to precised location and can also climb making it suitable for all terrain.

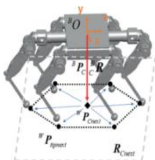
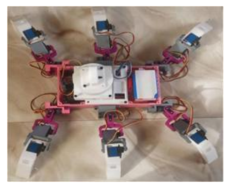
Table 6. Literature review 5

Author	Yue Zhao et al [14]	Chuntai et al [6]	He Zhang et al [16]	Mena et al [17]
Figures				
Fig number	16	17	18	19
Self-weight	-	-	3.2 kg	-
Payload	-	-	-	-
PWR	-	-	-	-

Liu et al [18] developed all terrain hexapod robots as shown in Fig 20, with adaptive posture control that enables stable locomotion irrespective of any constrained environment. Ilya

Brodoline [19] proposed ahexapod robots as shown in Fig 9, working with full servomotor based by applying the law of thermodynamics. Tooki et al [20] developed hexapod robots as shown in Fig 22, for real time surveillance with telemetry for stable movement. The PWR value of bot is 0.66. Sugimoto et al [21] introduced 30 mm micro hexapod robots as shown in Fig 23, with Su-8 and MEMS mainly applied in disaster surveillance.

Table 7. Literature review 6

Author	Liu et al [18]	Sun et al [7]	Tooki et al [20]	Sugimoto et al [21]
Figures				
Fig number	20	21	22	23
Self-weight	-	-	-	2.17 gram
Payload	-	-	250 gram	-
PWR	-	-	-	-

Ouyang et al [22] proposed an adaptive locomotion control approach for hexapod robots as shown in Fig 24 It is being inspired from biological neuro control system. Zhong et al [23] proposed an adaptive stable locomotive suitable for all terrain hexapod robots as shown in Fig 8. It is developed for agriculture purpose. The PWR value of this bot is 0.8. Arrigoni et al [24] used MATLAB for predicting the dynamic of lightweight hexapod robots leg as shown in Fig 25, Fucek et al [25] proposed yaw algorithm to control the locomotion of hexapod robots in lab test as shown in Fig 26.

Table 8. Literature review 7

Author	Ouyang et al [22]	Arrigoni et al [24]	Fucek et al [25]
Figures			
Fig number	24	25	26
Self-weight	2 kg	1×10−5 light weight	-
Payload	-	-	-
PWR	-	-	-

Bin Min Shu et al [26] developed a central pattern generator signal to control the movement of legs in hexapod robots(as shown in Fig 27), which is employed for lunar exploration. Min Chan Hwang [27] developed a hexapod robots(as shown in Fig 28), with non-collocated actuator which enables the tripod stabilities even in absence of battery power. Zhiying Qiu et al [28] proposed an optimized Gait mechanism adapting for any critical environment by employing hierarchical framework and reinforcement learning (as shown in Fig 29),

Table 9. Literature review 8

Author	Bin Min Shu [26]	Min Chan Hwang [27]	Zhiying Qiu [28]
Figures			
Fig number	27	28	29
Self-weight	1.42 kg	-	10 kg
Payload	-	-	-
PWR	-	-	-

Guillaume Sartoretti et al [30] designed a hexapod robots (as shown in Fig 30) in MARMot lab which has standing payload capacity of 5kg and dynamic payload capacity of 2kg. C.Zhang et al [31] proposed a hexapod robots(as shown in Fig 31), used transmission mechanism for enhancing the dynamic mechanism of legged robot in hexapod robots. Haichuang Xia [29] proposed a method to determine the trajectectory movement of hexapod robots leg as shown in Fig 32, in a given Cartesian space using triangle gait.

Table 10. Literature review 9

Author	Guillaume Sartoretti [30]	C. Zhang et al [31]	Haichuang Xia [29]
Figures			
Fig number	30	31	32
Self- weight	-	-	-
Payload	2kg	-	-
PWR	-	-	-

8Discussion

8.1 Key findings:

Hexapod robots continue to represent one of the most versatile and robust legged locomotion platforms in robotics. Their inherent static stability, high payload capacity, and adaptability to uneven or unpredictable terrains make them ideal candidates for exploration, inspection, search-and-rescue, and industrial applications. This review has highlighted the major advancements in mechanical design, actuation technologies, gait generation, control strategies, and sensing integration that collectively define the current state of the art. Although significant progress has been made, key challenges remain—particularly in improving energy efficiency, enhancing autonomy in unstructured environments, and developing lightweight yet powerful actuation systems. Hexapod robots wall-climbing robots combine the advantages of multi-legged stability with novel adhesion technologies, creating platforms capable of navigating vertical and inverted surfaces that are inaccessible to conventional robots. As these technologies mature, hexapod robots wall-climbing robots hold significant potential for inspection, maintenance, and monitoring tasks across high-risk or hard-to-reach structures, making them a critical and growing domain within climbing robotic

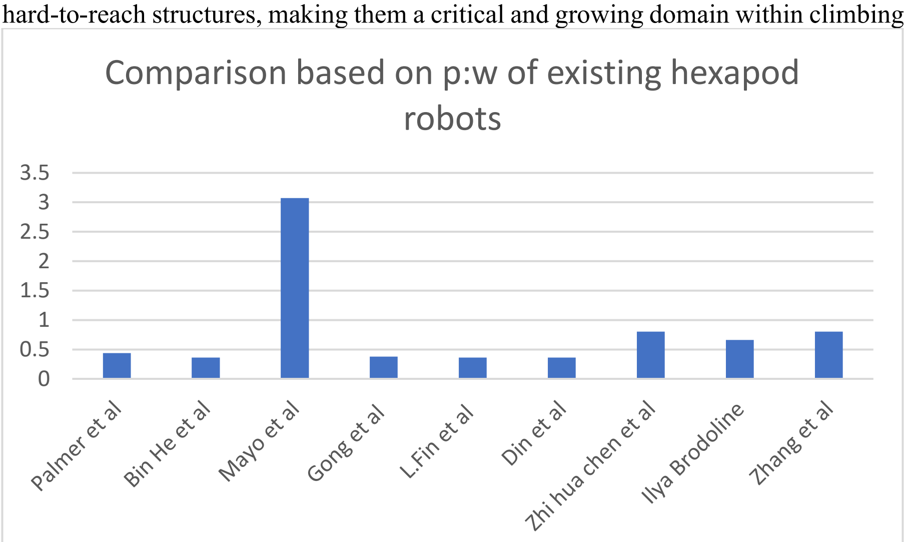


Fig.36. Comparison of PWR of existing Hexapod robots

Limitations

The literature review is made based on comparing the payload and self-weight value of the existing hexapod robots where actual experimental or prototype validation is not considered for the comparison parameter.

Future works

Stress path, load distribution, or joint torque analysis, scaling laws (link length Vs payload Vs mass), mechanical design principles can be included in the future work for the literature review of all hexapod robots

9Conclusion

Figure 36 shows the comparison of existing hexapod robots based on their PWR value. The review indicates that only very few research articles are available on hexapod robots-type wall-climbing robots and most of the research work has been done on horizontal-surface walking hexapod robots. With these available research papers in which the payload and weight values are mentioned, the hexapod robots design proposed by Mayo et al [3] has the highest PWR value of 3.07. More research can be done focusing on this hexapod robots-type wall-climbing robot, with the aim of increasing its PWR value beyond the existing highest value (i.e.)3.07. an appropriate novel design change or innovative feature modification of the existing wall-climbing hexapod robots will result in an increase in PWRvalue. Efficiency and endurance versus safety and payload capacity, Safety and stability versus speed of movement., Lightweight design versus mechanical robustness, Terrain flexibility against expense and ease of control,Multi-surface capability versus reliability,manoeuvrability versus inspection capability, Energy efficiency versus operational safety are the key design trade off of hexapod robots wall climbing robot which can be considered for the future work. Most of the clustering of PWR values ranges from 0.3 to 0.8 because of the design constraints of the hexapod robots.

Acknowledgement

The authors acknowledge the contributions of researchers in the field of hexapod robots robotics whose work formed the basis of this review

Funding

The seed money offered for research from PMIST is utilized in this research work.

Conflict of interest

None declared

Author contribution

1. Dr.R. Rakesh – Concept developer and Contributed in Simulation
2. P.Yazhisai – Contributed towards literature review
3. S.Suvathi – Contributed in fabrication of bot
4. S.Parkavi – Contributed in drafting the work

Ethics approval

There is no specific data with required ethics approval

Data availability

Data can be shared based on individual request

References

1. Ausama et al., "A Miniature Legged Hexapod Robot Controlled by a FPGA," International Journal of Mechanical Engineering and Mechatronics, (2013).
2. B. He, S. Xu, Y. Zhou, Z. Wang, “Mobility properties analyses of a wall climbing hexapod robots robot”, J. Mech. Sci. Technol. 32, 1333–1344 (2018).
3. M. Funatsu et al., Development of cm-scale wall climbing hexapod robots robot with claws, MM Sci. J., 101–106 (2014).
4. C. Gong et al., “Agile plane transition of a hexapod robots climbing robot”, IEEE Robot. Autom. Lett. (2025).

5. L Fan et al., "Agile Plane Transition of a Hexapod Climbing Robot," in IEEE Robotics and Automation Letters, vol. 10, no. 6, 5959-5966, (2025)
6. Chuntai et al., "Degree of freedom analysis of hexapod wall-climbing robot," 16-2016-217 (2016).
7. C. Sun et al., RHex-T3: A transformable hexapod robots robot with ladder climbing function, IEEE/ASME Trans. Mechatronics 28, 1939–1947 (2023).
8. G. Hongfan, Z. Zhangyan, Obstacle climbing gait design of hexapod robots wall climbing robot, Mech. Ind. 24, 20 (2023).
9. Heming Hu et al., "Research on Kinematics and Stability of a Bionic Wall-Climbing Hexapod Robot," Applied Bionics and Biomechanics, 1-17 (2019).
10. C. Nguyen et al., Development of an insect-inspired hexapod robots robot actuated by soft actuators, J. Mech. Robot. 10, 061016 (2018).
11. J. Wei et al., Adaptive sliding mode control for foot trajectory of hexapod robots robot, Trans. Can. Soc. Mech. Eng. 48, 617–626 (2024).
12. L. Ding et al., “Design of a deep-sea multimode crawling–swimming hexapod robots robot”, Ocean Eng. 280, 114485 (2023).
13. Huayang Li., "Implementing the Analytical Reachable Body Workspace for Calculating the Obstacle-Crossing Ability of a Hexapod Robot," 15-6-06-1017 (2023).
14. Yue Zhao et al., "Terrain classification and adaptive locomotion for a hexapod robot,"271–284, (2021).
15. Zhihua Chen., “Control strategy of stable walking for a hexapod wheel-legged robot”, 367–380 (2021).
16. He Zhang et al., "Research on the Posture Control Method of Hexapod Robot for Rugged Terrain," 10-19-6725 (2020)
17. Mena et al., "Reconfiguration of a Climbing Robot in an All-Terrain Hexapod Robot," Advances in Intelligent Systems and Computing, vol 418. Springer (2015).
18. H. Liu et al., Staircase-climbing capability-based dimension design of hexapod robots robot, Mech. Mach. Theory 164, 104400 (2021).
19. Ilya Brodoline., "Shaping the energy curves of a servomotor-based hexapod robot", scientific Reports volume 14, Article number: 11675 (2024).
20. Tooki et al., "Development of an intelligent-based telemetry hexapod robotic system for surveillance of power system components," e-Prime - Advances in Electrical Engineering, Electronics and Energy,Vol 10, 2772-6711 (2024).
21. Sugimoto et al., "Micro-hexapod robot with an origami-like SU-8-coated rigid frame," Published online by Cambridge University (2024)
22. W. Ouyang et al., Adaptive locomotion control of hexapod robots robot, Front. Neurorobotics. 15, 627157 (2021).
23. B. Zhong et al., On a CPG-based hexapod robots robot, IEEE/ASME Trans. Mechatronics 23, 542–551 (2018).
24. S. Arrigoni et al., Control of a hexapod robots robot considering terrain interaction, Robotics 13, 142 (2024).
25. L. Fucek et al., Yaw control algorithm for hexapod robots robot, Int. J. Adv. Robot. Syst. 16, 1729881419857997 (2019).
26. B.M. Shu et al., Structure and gait design of lunar explorationhexapod robots robot, Actuators 13, 79 (2024).
27. M.C. Hwang et al., Design and building of a hexapod robots robot with biomimetic legs, Appl. Sci. 9, 2792 (2019).
28. Z. Qiu et al., Adaptive gait generation for hexapod robots, Actuators 12, 75 (2023).

29. H. Xia et al., Foot trajectory planning method for hexapod robots, Appl. Sci. 11, 9217 (2021).
30. G. Sartoretti et al., Distributed learning of decentralized control policies, IEEE Trans. Robot. 35, 1109–1122 (2019).
31. C. Zhang et al., Energy consumption optimization of agricultural hexapod robots robot, Trans. Chin. Soc. Agric. Eng. 32, 73–83 (2016).