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Study and Development of Strider Linkage Legged Robot's Movement with HuskyLens AI Vision Camera

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ABSTRACT

This paper presents the design, development and evaluation of a legged robot based on a 10-bar Strider linkage mechanism, aimed at achieving stable straight-line locomotion with and without a HuskyLens AI vision camera. Unlike conventional legged robots that depend on complex gait algorithms, this approach leverages mechanical linkage geometry for natural walking motion. The robot chassis and legs were fabricated using Polyethylene Terephthalate Glycol (PETG) via 3D printing due to its superior tensile strength (~50 MPa) and high heat resistance. An Arduino Uno microcontroller, integrated with a HuskyLens AI vision camera, was used for line tracking and control. Performance testing assessed time, speed and energy efficiency across 20 experimental trials over a 5-meter course. Quantitative results indicate that while the mechanical design alone allows straight movement initially, open-loop cumulative drift caused the unassisted robot to fail completely after Trial 10 (0% success rate from Trial 11 onwards). Conversely, the AI-enhanced control closed the feedback loop, ensuring a 100% trial completion rate while mitigating drift through real-time trajectory adjustments, demonstrating a robust trade-off between minimal processing overhead and path-tracking accuracy.

Keywords: Arduino Uno, HuskyLens AI Vision Camera, Strider Linkage Legged Robot

1. INTRODUCTION

Legged robots offer superior terrain adaptability over wheeled counterparts, especially in uneven or unstructured environments where wheels may lose traction or become stuck. Their ability to replicate biological locomotion makes them suitable for exploration, search-and-rescue and industrial tasks. However, conventional multi-legged robots rely heavily on computationally intensive gaits and numerous high-torque actuators, resulting in high power consumption and complex control architectures.

To address these limitations, this research focuses on developing a simple, mechanically driven robot using a 10-bar Strider linkage mechanism to maintain stable locomotion without complex algorithmic gait generation. The primary novelty and contribution of this work lie in the integration of an edge-computing AI vision camera (HuskyLens) with a rigid linkage-

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based walker. While pure linkage mechanisms suffer from inevitable direction drifting due to minor structural defects and terrain friction asymmetric forces, the developed hybrid system corrects trajectory deviations in real time using minimal electronic processing overhead. By simplifying the mechanical coordination and localizing the vision processing, this project produces a highly reliable, efficient and low-cost robotic alternative to expensive multi-axis servo systems.

2. RELATED WORK

This section reviews prior studies relevant to linkage mechanisms, 3D printing materials, vision systems and foot designs, framing the structural decisions made during development.

2.1 Types of Linkage Mechanisms

Three common linkage mechanisms in legged robotics are Klann, Jansen and Strider linkages. Klann linkage is known for its simplicity and robustness on uneven terrains, using fewer links but resulting in limited foot trajectory smoothness [1][2][3]. Jansen linkage, in contrast, produces a more natural gait but is highly complex, with strict dimensional tolerances [4][5]. Strider linkage offers a balance, with smoother trajectories than Klann and less complexity than Jansen [6][7]. It also provides better forward motion consistency, making it suitable for robots intended to traverse various surfaces in a straight line. Prior studies confirm its performance efficiency in LEGO-based prototypes and validate its applicability to real-world mobile robotics [7]. Table 1 compares three linkage mechanisms: Klann, Jansen and Strider. The Klann linkage is the simplest with only six links, but resulting in a less smooth foot trajectory, limiting stability. The Jansen linkage, with 11 links, offers a smoother gait, but is more complex and costly. The Strider linkage strikes a balance, using 10 links to provide smoother movement than Klann while maintaining lower complexity than Jansen. It ensures consistent forward motion and better adaptability across surfaces, making it an ideal choice for real-world applications. The Strider linkage offers a practical solution with optimal performance, simplicity, and cost-efficiency, making it the best option for this robot.

2.2 3D Printing Filament Types

The choice of 3D printing material in Table 2 shows significantly affects the robot's strength, durability, and performance. PLA, though easy to print, is brittle and unsuitable for high-load applications. ABS offers higher toughness but emits fumes and requires a heated chamber [8] [9]. PETG emerges as the optimal material due to its combination of high tensile strength, flexibility, ease of printing and resistance to environmental stress [10]. Experiments have shown PETG maintains structural integrity during continuous mechanical stress, making it ideal for printing functional robotic components such as legs and linkages [7].

Table 1 Comparison of 3 types of linkages

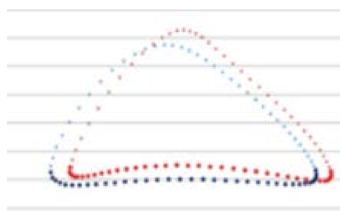
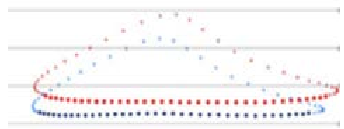
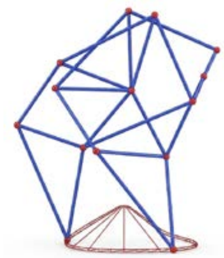
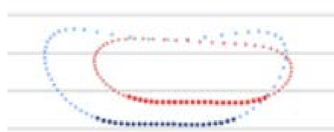
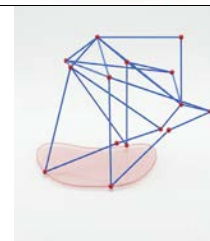
Robot Linkages	Specifications			
	Number of Link	**Foot Locus**	**Complexity**	**Linkage Design**
Klann	6		Low	
Jansen	11		High	
Strider	10		Medium	

Table 2 Comparison of 3 types of 3d print filament

Properties	PLA	PETG	ABS
Tensile strength	~ 60 MPa	~ 50 MPa	~ 40 MPa
Flexural strength	~ 100 MPa	~ 90 MPa	~ 70 MPa
Impact strength	Low	Medium	High
Young's modulus	~ 3.0 to 3.5 GPa	~ 2.0 to 2.22 GPa	~ 2.1 to 2.5 GPa
Heat resistance (HDT)	~ 55 to 60 °C	~ 70 to 80 °C	~ 85 to 100 °C
Printability	Easy	Easy	Moderate
Durability	Moderate	High	High

2.3 HuskyLens Vision Camera

The HuskyLens is an AI-powered vision camera equipped with an on-board machine learning processor capable of executing line tracking, object recognition and face detection independently [11]. In this project, its line-tracking mode provides autonomous closed-loop directional corrections to the main microcontroller [12]. This allows the robot to correct deviations from the intended path [13]. The advantage of HuskyLens lies in its onboard processing, reducing computational load on the main controller.

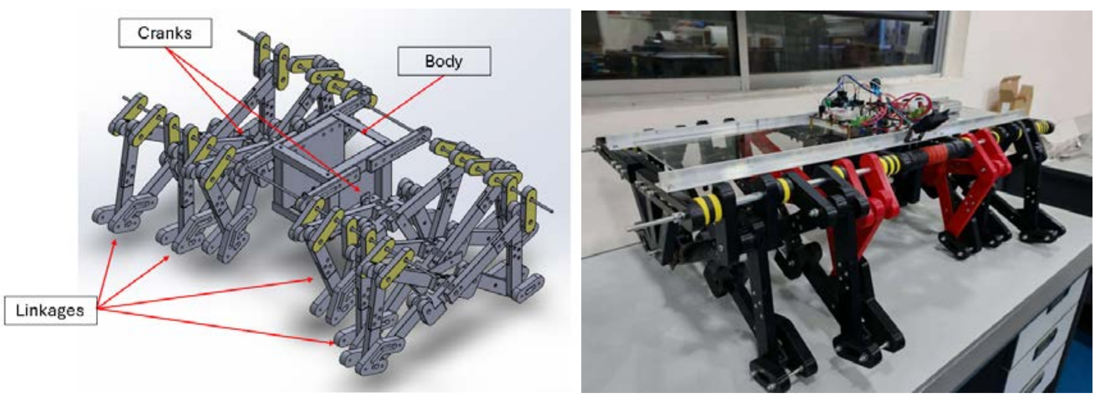
2.4 Foot Design Considerations

Robotic foot design significantly influences mobility, shock absorption and surface adaptability [14]. Bio-inspired designs that mimic tendons or compliant mechanisms have been shown to enhance grip and reduce impact stress [9]. Studies on heavy-duty legged robots suggest the importance of selecting foot shapes (e.g., semi-cylindrical or spherical) based on terrain type [15]. Although this project employs a simple flat foot design, future versions might consider compliant materials and textured surfaces to improve ground contact and friction across diverse environments [16][17].

3. MATERIAL AND METHODS

3.1 Mechanical Design and Reproducibility Specifications

Figure 1 presents both the SolidWorks model and the fabricated physical structure of the robot. The physical architecture was designed in SolidWorks to ensure symmetrical weight distribution along its central axis. The robot features a modular chassis housing two mirrored sets of 10-bar Strider linkages, providing a total of 8 synchronized legs to maintain continuous multi-point ground contact.



(a) SolidWorks model (b) 3D printed

Figure 1. Strider robot design

All structural components were printed via Fused Deposition Modeling (FDM) using premium PETG filament. To facilitate replication, the precise 3D printing parameters used were: a nozzle temperature of 240 °C, a bed temperature of 90 °C with an infill density of 100%.

3.2 Mechanical Design and Reproducibility Specifications

The robotic hardware system forms a closed-loop tracking architecture driven by an Arduino Uno microcontroller as illustrated in Figure 2. Locomotion torque is supplied by two 12 V planetary DC gear motors (specification: 296 RPM, rated torque of 4 kg·cm), which drive the primary cranks of the left and right leg banks independently. Power is sourced from an 11.1 V (3S) 2200 mAh Lithium-Polymer (LiPo) battery pack routed through dual MD30B high-current motor drivers.

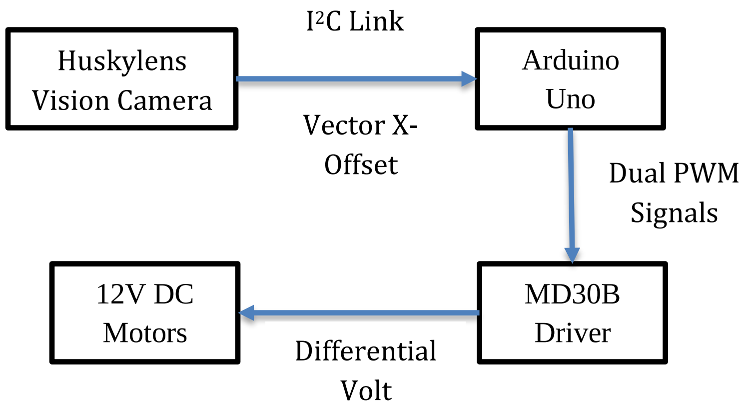


Figure 2. Robotic hardware system

The control interaction between the HuskyLens camera and the Arduino Uno operates as follows:

1. The HuskyLens is mounted rigidly onto the front frame facing downwards at a 45 °angle, continually tracking a high-contrast white path centre line.
2. The internal camera processor calculates the lateral error offset (Δ X) between the detected path center vector and the camera's absolute physical centre frame.
3. This position error is transmitted to the Arduino Uno at 20 Hz via an I^2C serial communication interface.
4. The Arduino executes a correctional control loop: if Δ X shifts left, the controller applies a differential PWM reduction (5-15 %) to the left motor driver while maintaining or increasing the right motor speed, dynamically swinging the mechanical chassis back onto the path axis.

3.2 System Architecture and Component Integration

The electronic system of the Strider linkage robot in Figure 3 integrates several key components to enable control and operation. At the core is the Arduino Uno microcontroller, which manages the robot's movement by controlling the 12V planetary DC gear motors that drive the robot's legs [18][19]. The motors provide the necessary torque to overcome surface resistance and maintain steady motion. A motor driver circuit is used to regulate the power supplied to the motors based on the Arduino's commands. Additionally, the HuskyLens AI camera is integrated into the system for vision-based feedback, allowing the robot to track lines and make real-time adjustments to its direction [13]. This setup allows the robot to move autonomously and efficiently, adjusting its course based on camera input while maintaining smooth locomotion across different surfaces [20].

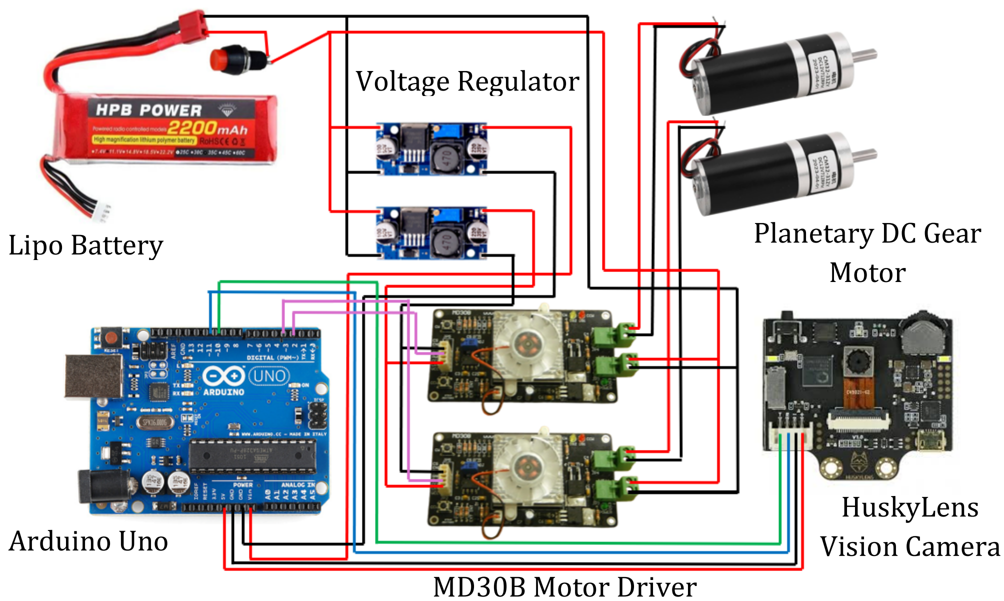


Figure 3. Electrical system

3.3 Experimental Setup

Testing was conducted in a controlled lab environment over a straight, clear 5-meter path marked with a central guidance track line, as illustrated in the experimental setup in Figure 4. Performance was evaluated across 20 sequential trials for two configurations: (1) purely mechanical open-loop operation, and (2) HuskyLens-assisted closed-loop operation. Three parameters were tracked continuously: total travel time (s) to cover the 5 m distance, computed linear velocity (m/s), and real-time operational battery voltage (V) to analyze system efficiency.

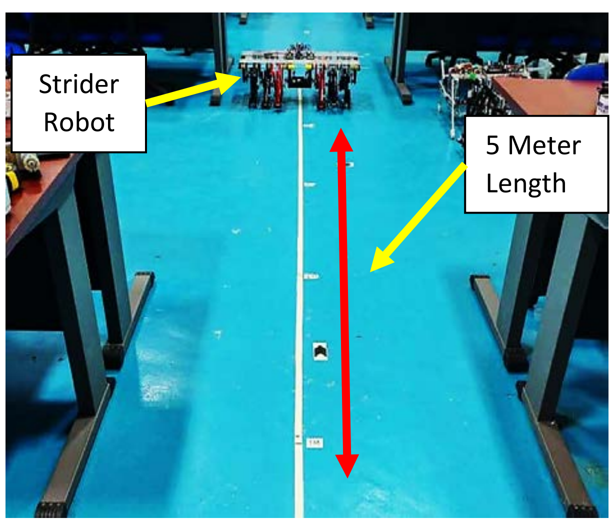


Figure 4. Test environment for robot performance evaluation

4. RESULTS AND DISCUSSION

The robot consistently maintained forward motion across both surfaces. On flat cement, motion was smooth with minimal deviation. On carpet, increased friction and material softness caused slight yawing, particularly in the non-camera-assisted mode. The integration of HuskyLens significantly reduced deviation and corrected minor misalignments by adjusting motor speeds dynamically. Speed tests showed a marginal increase in time when using vision control due to processing delay, but the improvement in directional accuracy outweighed this drawback. Voltage measurements during operation indicated steady power draw, confirming efficient energy usage. These findings reinforce the viability of combining mechanical linkage with minimal electronic control for robust locomotion. Comparisons of camera-assisted versus purely mechanical control emphasize the trade-off between simplicity and performance.

The graph in Figure 5 presents a comparative analysis of the time taken for the robot to complete a 5-meter walk across 20 trials. Initially, both robot configurations exhibited similar capabilities; however, their performance diverged sharply as the trials progressed. The robot without camera assistance failed from Trial 9 onwards, with its completion time recorded as zero as it was no longer able to cover the designated distance. In contrast, the camera-equipped robot successfully completed all 20 trials, despite a gradual increase in traversal time as battery levels declined. This underscores a significant advantage of the HuskyLens camera: it enables the robot to maintain directional accuracy and operational consistency even under reduced power conditions.

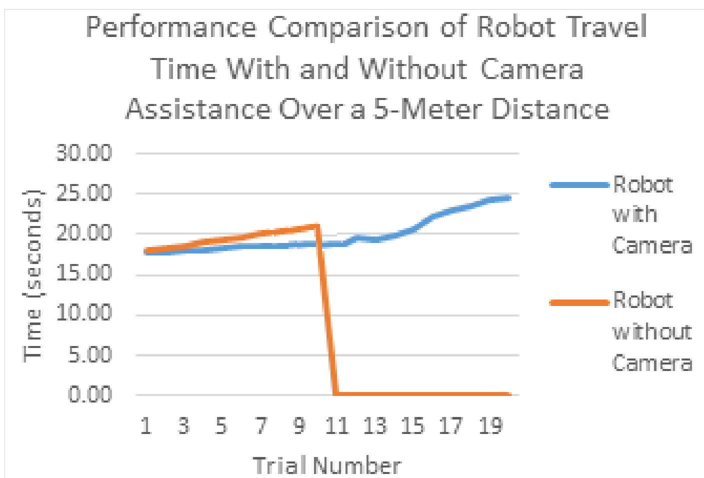


Figure 5. Analysis of travel time

Figure 6 illustrates the speed performance (m/s) of both modes, reinforcing the trends observed in the travel time data. The robot without the camera experienced a steep decline in speed, recorded as zero from Trial 9 onwards. Conversely, the robot with vision support maintained consistent movement, although its speed decreased slightly over time due to voltage decay. This disparity suggests that open-loop motor control, which lacks sensory feedback, cannot adapt to changes in terrain resistance or torque demands, leading to premature system failure. The integration of HuskyLens likely provided feedback-based corrections, allowing the robot to adjust its stride and heading to stay on course despite environmental or power limitations.

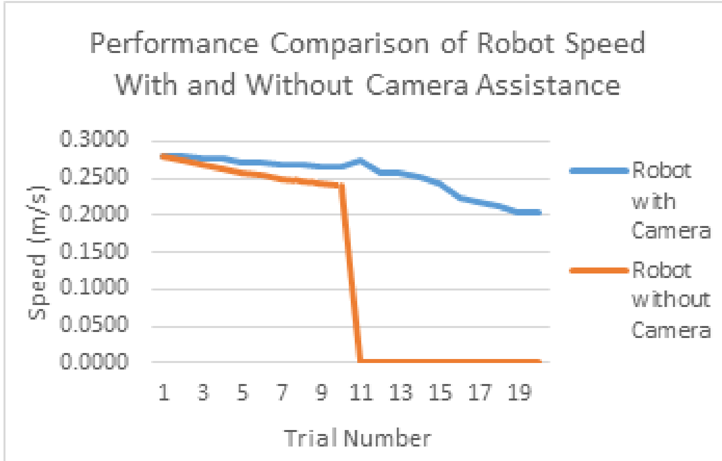


Figure 6. Analysis of speed and movement consistency

Figure 7 tracks the power consumption throughout the testing process, showing stable values between 11.8 V and 12.4 V for both configurations. While both exhibit similar trends in voltage decay, the camera-assisted robot consumed slightly more power, likely due to the energy requirements of the HuskyLens module. Despite this additional draw, the camera-enabled robot continued to operate successfully, proving that adaptability to friction and mechanical load is more critical to performance than power consumption alone. While camera integration increases calibration complexity, the graphs clearly demonstrate that it is essential for achieving robust and stable mobility, without camera feedback, the robot fails quickly once it reaches its operational limits.

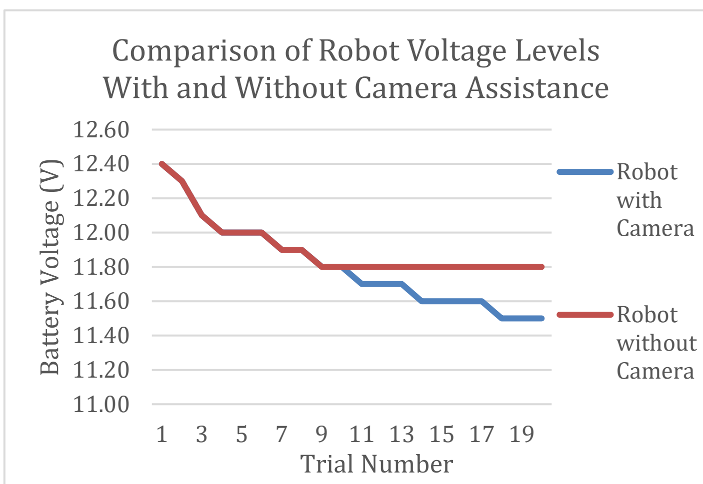


Figure 7. Analysis of voltage consumption and efficiency

5. CONCLUSION

This study validates the design and practical implementation of a hybrid 10-bar Strider linkage legged robot enhanced by a HuskyLens AI vision camera. The experimental results show that while pure mechanical geometry provides an efficient foundation for walking, sensory feedback is critical for long-term stability; without it, open-loop drift leads to complete system failure over extended distances. Integrating edge-computed vision feedback allowed the robot to achieve a 100% path-tracking success rate across all test cycles by correcting trajectory deviations in real time.

5.1 Practical Applications

The low computing requirements and high mechanical stability of this architecture make it well-suited for autonomous transport platforms, simple agricultural crop monitoring and remote industrial inspection tasks on predictable, low-traction surfaces.

5.2 Future Extensions

Future work will focus on replacing the rigid flat feet with compliant, textured elastomer pads to reduce impact forces and increase ground friction. Additionally, there will be plans to implement a Proportional-Integral-Derivative (PID) control algorithm on the Arduino Uno to smooth out differential steering corrections and further reduce path-tracking errors.

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