

# Biomimetic Climbing Robot Design Inspired by Geckos and Cats for Rough Wall Applications

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**Abstract:** This research presents the design of a quadrupedal robot capable of climbing rough surfaces. The robot's shape, body, arms, and locomotion mechanism were inspired by the gecko, while its limbs were inspired by the limbs cats used to climb trees and grip rough surfaces. The robot has three degrees of freedom. Its grasping limbs were designed in an arched shape, with each limb equipped with seven claws so that each hook moves independently on the wall without overlapping. The arms were designed in a parallelogram shape and at the same level as the robot's body to ensure stability during climbing and maintain the robot's center of gravity close to the wall surface, enhancing gripping force and reducing the risk of slipping or falling. These features enable the robot to grasp, cling, and climb rough surfaces with greater ease. The motion algorithm applied to the climbing robot was inspired by the gecko algorithm, and a kinematic model was developed to calculate the displacement and position of the robot arm's end-receiver. The robot's body was designed using SolidWorks, and the robot's body was fabricated and implemented using a 3D printer. Some system kinematics calculations were performed using MATLAB. **Several climbing experiments were conducted on rough surfaces at 75° and 85° inclinations. In 15 trials on a 75° slope, the robot achieved a success rate of 93% demonstrating reliable performance. The robot's climbing speed ranged from 20 to 60 cm/min.** The experiments demonstrated the robot's ability to climb and navigate on rough surfaces and uneven terrain efficiently and with stable performance.

**Keywords:** Climbing Robot, rough surfaces, Claw, kinematic model

## 1- Introduction

In recent years, robotics has advanced significantly, extending beyond industrial fields to include areas such as the military, surveillance, and monitoring. Among these robots, the climbing robot is the most important. The significance of using climbing robots on various vertical surfaces lies in their ability to perform tasks that are difficult to reach due to the risks associated with high places, such as the walls of tall buildings, which pose serious threats to workers, or because of the high costs. Robots can handle hazardous environments that put individuals at risk [1-5].

One of the most prominent challenges facing researchers in the field of wall-climbing robots is achieving sufficient adhesion on various surfaces while ensuring a reliable level of effectiveness. Consequently, diverse adhesion methods offer significant opportunities and key areas of focus for scientific research in wall-climbing robots. Thus, wall-climbing robots can be categorized according to their adhesion methods into several groups, including magnetic adhesion, vacuum suction pads, and biologically inspired systems [6-12].

Biologically inspired methods can be applied to various surfaces and do not necessarily require specific means to create adhesion. One type of method inspired by nature for climbing and grasping rough surfaces is the claw-like technique used by cats, as well as the climbing mechanisms of geckos. Through continuous observation and monitoring of these climbing animals, which are renowned for their ability to navigate rough terrains, researchers have developed new adhesion techniques and methods inspired by their unique adaptations. Robotic limbs are equipped with fishing hooks that mimic claws, enabling them to grasp, grip, and climb over rough surfaces such as concrete and brick. For instance, a robot with limbs containing miniature spikes can ascend rough walls by embedding the spikes into the uneven terrain. Climbing robots equipped with claws to traverse these challenging surfaces represent advanced technology that allows robots to adapt to irregular terrains that pose difficulties for conventional robots. Such irregular surfaces, characterized by roughness and unevenness, like rocks and trees, can complicate movement. Claws provide the necessary frictional force to stabilize the robot on these surfaces, thereby enhancing stability during climbing. Consequently, robots that utilize claws for climbing offer promising opportunities in various fields, particularly in rescue, inspection, and surveillance operations, thereby expanding the horizons of scientific research [2,3,7,13-19].

Some animals with the ability to climb and cling have become an inspiration source for researchers, as bionic technologies such as claws on cats are a typical technique for creating adhesion [20]. We will provide an overview of the mechanical adhesion method used in climbing robots to a group of researchers who have developed or used wall-climbing robotic technologies.