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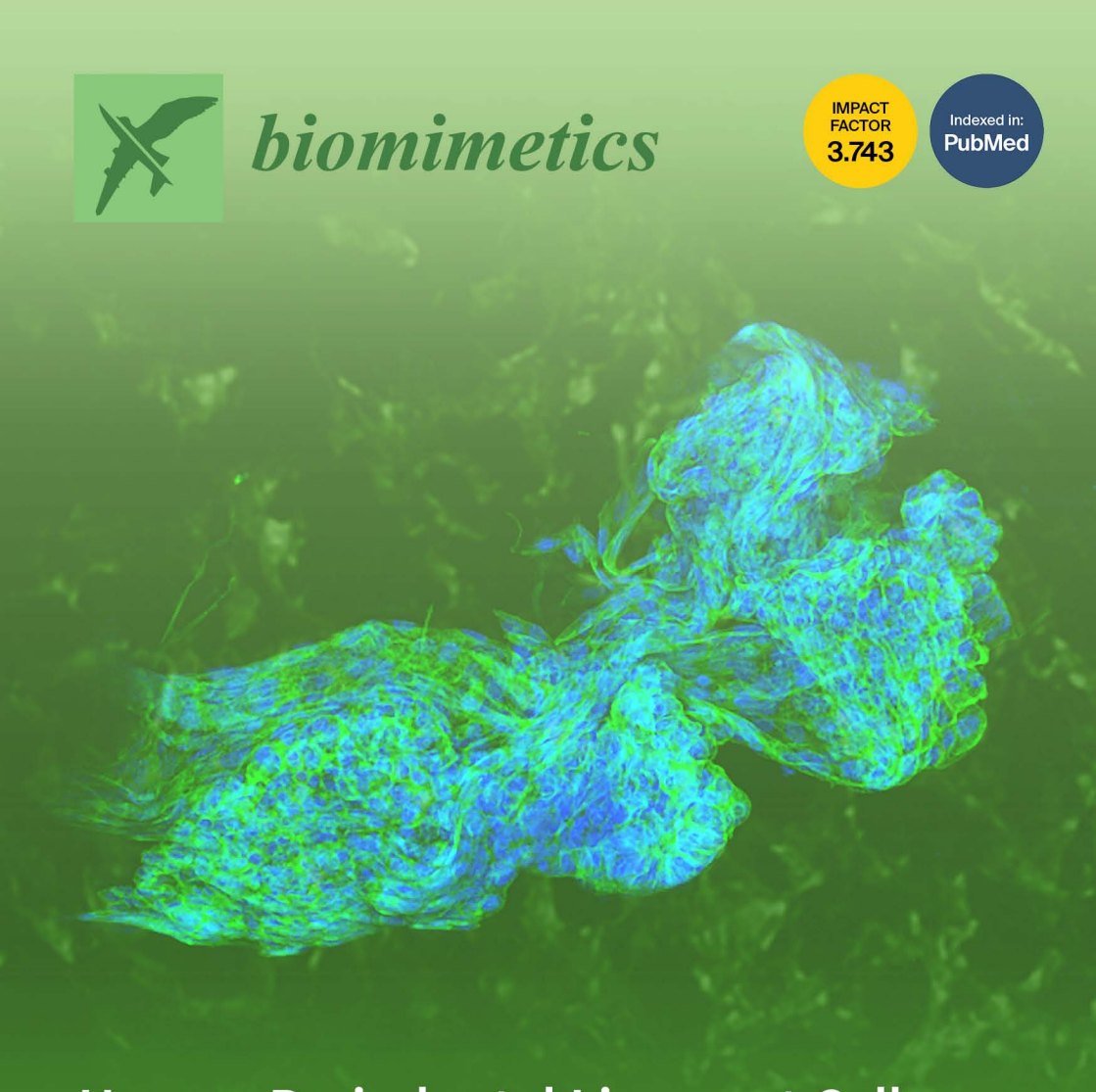

Human Periodontal Ligament Cells Colonizing an Electrospun Fibrous Scaffold

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Review

Advances in Climbing Robots for Vertical Structures in the Past Decade: A Review

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Review

Advances in Climbing Robots for Vertical Structures in the Past Decade: A Review

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Abstract: Climbing robots are designed to conduct tasks that may be dangerous for humans working at height. In addition to improving safety, they can also increase task efficiency and reduce labor costs. They are widely used for bridge inspection, high-rise building cleaning, fruit picking, high-altitude rescue, and military reconnaissance. In addition to climbing, these robots need to carry tools to complete their tasks. Hence, their design and development are more challenging than those of most other robots. This paper analyzes and compares the past decade's design and development of climbing robots that can ascend vertical structures such as rods, cables, walls, and trees. Firstly, the main research fields and basic design requirements of climbing robots are introduced, and then the advantages and disadvantages of six key technologies are summarized, namely, conceptual design, adhesion methods, locomotion modes, safety mechanisms, control methods, and operational tools. Finally, the remaining challenges in research on climbing robots are briefly discussed and future research directions are highlighted. This paper provides a scientific reference for researchers engaged in the study of climbing robots.

Keywords: vertical structure; climbing robot; application fields; adhesion mechanism; locomotion mode; control mode; operation tools

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1. Introduction

Climbing robots can replace human workers in tasks where they are required to climb along vertical or near-vertical objects. They can carry tools to conduct a wide range of hazardous tasks, such as detection, monitoring, cleaning, maintenance, installation, spraying, fruit picking, pruning, search and rescue, and so on. They are widely used in bridges, ships, chimneys, pipelines, streetlamps, nuclear power plants, wind power generation, high-rise buildings, agricultural picking, and other fields.

Since the first climbing robot, Mod-I, was developed by Nishi et al. [1] in the 1960s, climbing robots have attracted the attention of many research institutions and scholars. A large number of scientific research achievements and robot prototypes have emerged. In the past decades, scholars from all over the world have summarized the climbing robots made for use in different fields. Yun et al. [2] discussed the development status of bridge-cable-climbing detection robots. Megalingam et al. [3] summarized the technologies related to coconut-tree-climbing robots. Solanki et al. [4] elaborated on two key technologies of wall-climbing robots—the attachment method and motion mechanism. Fang et al. [5] reviewed the research progress of three different motion modes of wall-climbing robots: wheeled, crawler, and legged. In addition, they summarized four different adsorption technologies used in wall-climbing robots: negative-pressure adsorption, magnetic adsorption, bionic adsorption, and electrostatic adsorption. Seo et al. [6] summarized the climbing mechanisms, cleaning methods, and applications of robots used to clean the glass and facades of high-rise buildings. Cai et al. [7] and Hou et al. [8] discussed the research status of robots used for high-rise buildings and for defect detection on bridge cable surfaces,