Snake-Inspired Modular Multi-Segment Pneumatic Climbing Robot for External Pole-like Infrastructure Exploration

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Climbing robots are a potential solution for exterior maintenance, inspection and replacement of urban pipe systems, column buildings and pole structures. In response to the space limitations and vulnerability of traditional rigid climbing robots, this research aims to develop a flexible climbing robot designed for exterior maintenance tasks on pole structures. The developed robot is engineered to efficiently climb, bear substantial loads, and easily integrate, while also boasting multi-functionality and environmental compatibility. Inspired by the locomotion of snakes and inchworms, two versions of the climbing robot are developed. The initial design employs a spiral shape and PE corrugated tubing for maneuvering on pole structures. It is driven by air pumps and valves, with 3D printed components facilitating assembly. Featuring multiple segments, including an extending structure in the middle and winding structures at the front and rear sections, the robot achieves a maximum speed of 2.7 cm/s and a load capacity of 900 grams in experimental tests using pneumatic propulsion and Bluetooth control. To enhance climbing versatility across surfaces with varying shapes, curvatures, and friction constants, an updated version of the climbing robot incorporates silicone bellows tubes and a ring-like winding structure. Utilizing a modular design, this version allows for disassembly and assembly of individual components through a cell phone interface. Additional winding or expanding structures can be incorporated as needed to enhance load capacity and climbing speed. Integration of a camera module enables inspection capabilities during maintenance operations, further augmenting the robot's functionality in infrastructure settings.

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