

An Analysis of the Progress Made Towards the Creation of a Wall-Climbing Robot for Cleaning Purposes

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Abstract

This article presents a climbing robot concept inspired by the Trek-o-bot model and the Trek-o-bot vacuum motor technology for climbing walls. For theoretically building a climbing robot based on a current literature review. The suggested technique is shown using a case study of ongoing research at Southborough University, the exploration of an adaptive and energetically autonomous climbing robot. With an extra connection provided to the robot for cleaning.

Keywords: - Concept of Climbing of robot, Modification to Wall Cleaner.

INTRODUCTION

Climbing robots are uncommon mobile robots with energy autonomous behavior, a strong and efficient adhesion mechanism, an agile locomotion mechanism, and intelligent sensors combined together so that they can adapt to diverse wall surfaces and 3D terrains to do specific tasks. Climbing robots may be capable of replacing humans in risky and time-consuming tasks for terrestrial and space applications with great efficiency

and low cost. Health and safety issues can be addressed by removing humans from dangerous or difficult-to-access locations. Meanwhile, the expense of employing operators or scaffolding can be reduced. Since the seminal work in [1,] a plethora of climbing robots [2, 3, 4, 5] have been designed to clean high-rise buildings (cleaning), inspect large structures such as bridges, solar power plants, and confined pipelines, among others (inspection), detect cracks in oil tanks, aircrafts, and

nuclear power plants, among others (testing), paint and maintain surfaces of ship hulls, wind turbines, and conduct welding for stainless steel tanks, among others (construction and maintenance). Furthermore, climbing robots may be seen as excellent vessels for strengthening mobile robot autonomy and adaptability, as well as stretching the limitations of existing technologies to construct coherent systems integrated with varied technologies.

CASE STUDY

When making and testing prototypes of these types of robots, there are three main things to think about: 1) the adhesion technique, 2) the mechanism for moving, and 3) the mechanism for acting.

Climbing robots should be thin and light because thin ones are more difficult to rip off a vertical surface and lightweight ones are more stable on the substrate [6]. Chemical techniques, for example, are sophisticated and pricey therapies. Floating oil and grease adhere to skimming medium more easily than water, making it difficult and critical to create a good adhesion strategy that ensures reliable climbing on diverse wall surfaces while not compromising flexible movement and big payloads. Although

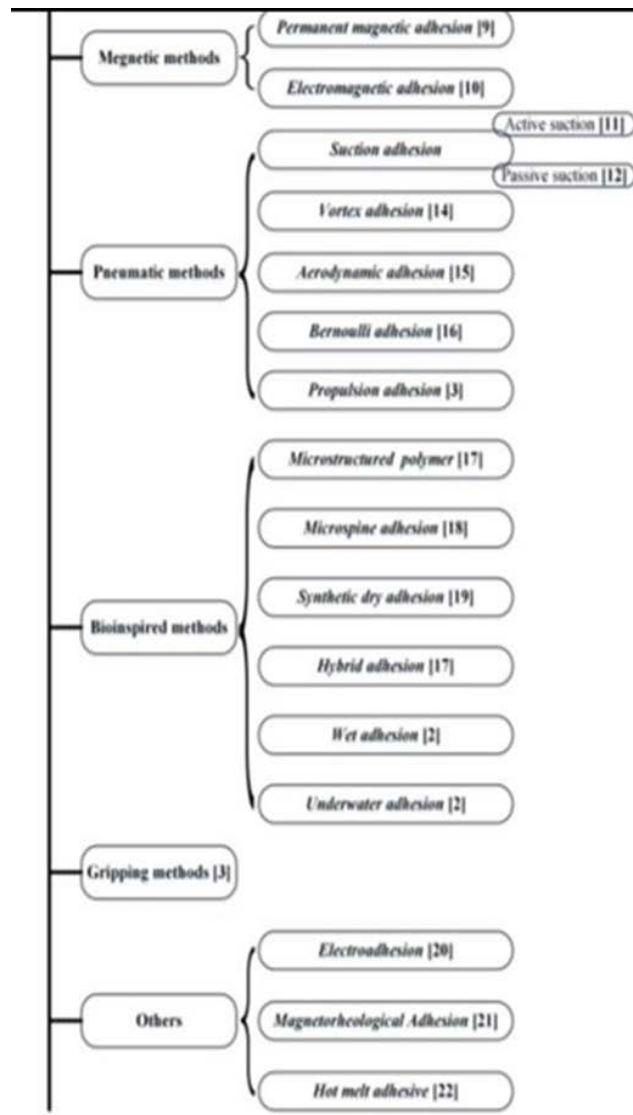
there have been several climbing prototypes since the 1980s, there is no universally acknowledged engineering design technique that can be applied to creating and prototyping climbing robots. This work identifies and proposes a concept selection approach for the early design stage of climbing robots based on an up-to-date literature assessment. Furthermore, there is no advanced climbing robot with complete autonomy and flexibility. To support themselves, most climbing robots are tethered or have on-board batteries. The former technique provides sufficient power to robots, but the weight of wires and their limiting lengths may limit their movement capacity. The latter strategy allows robots to behave autonomously. However, most batteries are insufficient for long-duration work. Climbing robots can realize long-range, long-duration missions without the need for manual or conventional re-fueling by combining energy-autonomous systems [7] with novel control methods (such as semantic control [8]), and enjoy a high level of energy-autonomous behavior like living creatures, increasing their adaptability and autonomy.

Figure 1 depicts the five primary kinds of adhesion mechanisms in climbing robots that have been outlined in this work. It

should be emphasized that although several more publications exist, just one sample work for each genre was listed.

Fig. 1: Adhesion mechanisms used in climbing robots. Magnetic adhesion technologies [9, 10] may provide quick and dependable movement as well as high adhesion forces. They are, however, only usable on ferromagnetic surfaces and are not energy efficient. Active suction techniques [11] and passive suction

methods [12] are two types of suction-based adhesion approaches. Suction-based climbing robots can climb over surfaces with any material and strong attachment forces, but they are only useful on relatively smooth and non-porous surfaces, are noisy, bulky, and have relatively high energy consumption, despite improvements such as a more efficient negative pressure generation mechanism [12] and a noise-less mechanism [13].



The tornado-inspired vortex adhesion [14] is quieter and more efficient since it does not require sealing devices and aspirators to produce the vacuum. Although an enhanced form of vortex adhesion, known as aerodynamic attraction, has been proposed [15] to improve payload capabilities and overall mobility, it produces unavoidably high noise, cannot be employed in space applications, and consumes substantial energy. Although Bernoulli-based adhesion, which is

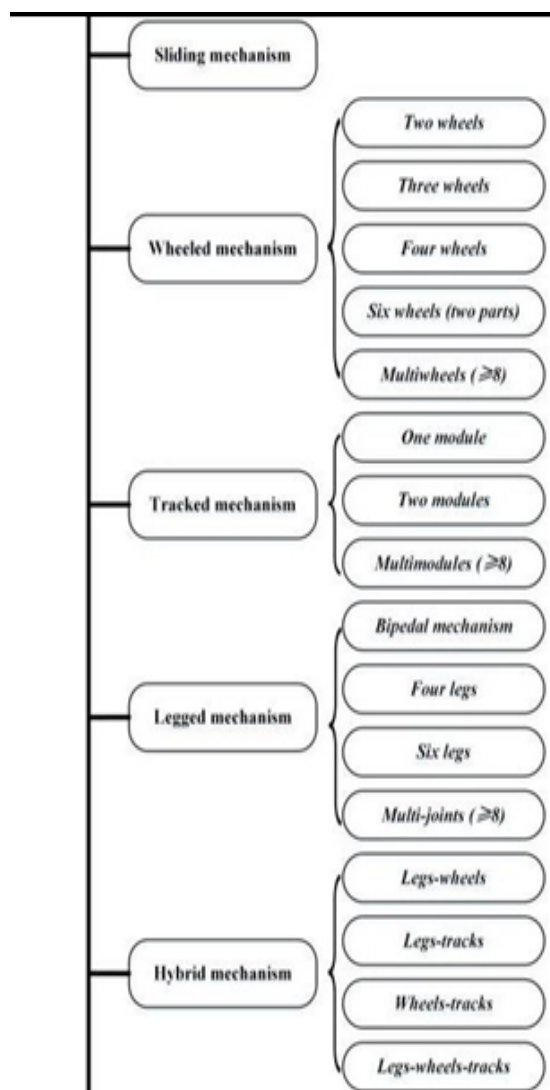
inspired by Bernoulli grippers, suffers from air stream noise and cannot be employed in space applications, it has an advantage over other approaches in terms of high force/weight ratio and flexibility to different surface conditions [16]. Propulsion-based climbing robots can climb many wall surfaces and are appropriate for tasking in wide areas with high mobility, but they create a lot of noise, take a lot of energy (typically tens of watts), can't be used in space, and are

difficult to manage [3]. The micro-structured polymer-based adhesive approach [17] is susceptible to contaminants and dust, limiting the use of climbing robots that employ this mechanism to smooth and clean surfaces. However, their self-cleaning capacity is immature, causing them to be contaminated and dusty. It is also costly and difficult to prototype robustly. A hybrid adhesion mechanism combines many processes, such as micro-spines and micro-structured polymer pads [17].

As a result, bio-inspired climbing robots can be more adaptable to climbing on different wall surfaces and performing complex wall transitions (such as vertical wall to ceiling transitions). This approach, however, is not yet developed enough and may result in quite dense structures. Wet adhesion inspired by snails is rarely employed, and underwater adhesion climbing robots [2] are specifically designed for usage in water. This paper will not go over them. Climbing robots based on gripping have been prototyped to walk through 3D irregular settings and rough surfaces such as poles, pipes and bridges, beams and columns, wire meshes, natural surroundings, and manufactured constructions [4].

They cannot, however, be used on flat surfaces. Although the adhesion forces generated per unit area by electro-adhesion are relatively weaker than those generated by other methods, and it may fail in high-moisture environments, electro-adhesion is a promising approach that allows robots to have several advantages, including adaptability to different wall surfaces, simpler and lighter structures, quiet and fast locomotion, and ultra-low energy consumption (usually microwatts) [20].

Climbing robots can adapt to a wide range of surface conditions with relatively high clamping pressures thanks to the magneto rheological fluids (MRFs)-based adhesion mechanism [21]. However, the climbing robot using this method is now unable to climb, and some fluids may be left on the wall substrates. Hot melt adhesive (HMA)-based adhesion may produce some of the strongest adhesion strengths (150 newtons per square centimeter), allowing the robot to adapt to any solid surface and unstructured terrain. They are, however, slow, consume a lot of energy, and frequently leave a trail [22]. Figure 2 depicts the five basic groups of locomotion processes outlined in this paper.



3 Proposed Conceptual Design Method

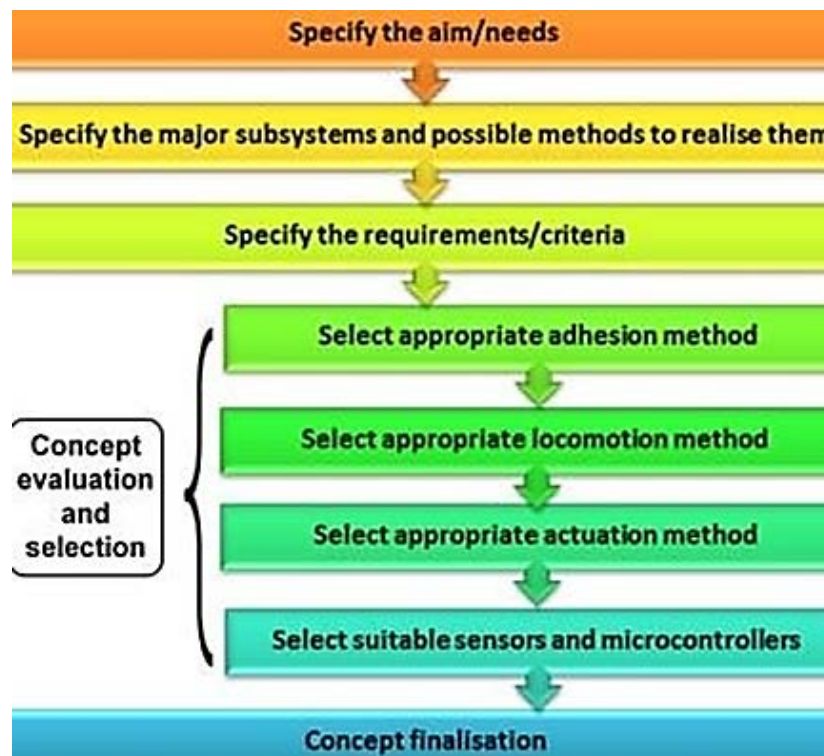


Fig.3

The VDI model [25] is one of the greatest attempts to demonstrate the influence of project complexity or scale. Because climbing robots are rather complicated systems that may be separated into the aforementioned major subsystems, Fig. 3 proposes and demonstrates a conceptual design selection technique inspired by the VDI model. It should be mentioned that this idea technique is very dependent on user needs, although it is appropriate because any design should fulfill user requirements enough.

The proposed method starts with specifying the aim or needs to be satisfied as precisely as possible, before specifying

the major subsystems and their possible solutions based on functional analysis (Such as the functional tree method). The investigation of an adaptable and energetically autonomous climbing robot for indoor applications is the aim of ongoing research in Southborough University.

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