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Design & Fabrication of Pneumatic Wall Climbing Robot

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Abstract: ***The purpose of this article is to present a survey on the inspection applications of Pneumatic Wall-Climbing Robot (PWCR). In general, a PWCR uses negative pressure as its adhesion method, primarily through a suction cup or a negative pressure-based-based Through non-ferromagnetic surfaces, such as their ability to climb glass and composite materials, compared to climbing robots based on magnetic adhesion methods. . Offering a significant application area PWCRs for inspection purposes to accelerate the time consuming processes of manual inspection, while offering significant benefits to protect human resources from dangerous and or unattainable environments. This article will summarize PWCR inspection enabled applications in the following areas: A) Construction, B) Industrial infrastructure, as well as C) Aircraft application***
Keywords: Suction cup ,Pneumatic hose, Sliding rod, Solenoid valve etc.

I. INTRODUCTION

The research area of the Wall-Climbing Robot (WCR) has received persistent interest over the years as a promising approach to remote inspection and access to large and difficult places. With the development of reliable WCR with inspection capabilities, there will be a significant reduction in maintenance cost in those areas where manual inspection time is high and compromise can be done with labor protection. Improved visual feedback and measurement possibilities can improve the overall process as well as improved quality inspection. A WCR can also work in environments which are dangerous for humans, such as chemical storage tanks or structures in greatness, hence the continued research on Wall-inspection robots are important for improving industrial safety.

While remaining on the sloping surfaces, many different adhesions and actions have been implemented in different combinations to solve the problems of pneumatic wall-climbing robot (PWCR) speed. The most common adhesion methods are: A) Magnetic, B) Pneumatic, C) Entertaining, and D) Biometric. For the use of magnetic adhesion method, the ferromagnetic requirements of the climbing material limit their general use for inspection, while adhesion methods suffer from its reliability on surrounding geometry, such as lead and rail. The main advantage of PWRR is their ability to climb a wide range of materials, such as composites, walls and tanks, ferromagnetic, as well as non-ferromagnetic This survey focuses on existing pneumatic adhesion methods for inspection robots and their applications.

There are two main pneumatic methods to obtain adhesion: A) Suction cups and B) Negative pressure-thrust . Suction cups (SCs) (Figure 1.2) are most used because of the simplicity of their design and operation theory. There is a continuous need of attachment / detachment to the surface to achieve a major loophole, thus limiting their speed. They suffer from vacuum leak over time, as well as the surface material has sensitivity to cracks and abnormalities, resulting in loss of adhesion force. This means that the SC-based robot servequistap-vare locomotion method, the claimed and translational movement, which enables the target surface and their attachment / detachment. On the other hand, negative pressure-thrust (NPT) adhesion (Fig. 1.1) has the advantage of supporting constant negative pressure, which increases the mobility of the robot. NPT usually applies the wheel movement to achieve continuous movement on the surface. The main drawback of the NPT is their advantage too, which means they do not need to contact with the target surface. It can save sensitive surfaces from damage during the LC, but produces the need to use high-power motors to achieve and maintain the required constant negative pressure.

The purpose and contribution of this article is to provide a survey on the inspection applications of PWCR, which will be classified as follows: A) Adhesion method, and B) Locomotive method, as well as their desired industrial inspection application area. Due to the promise of this technique, such survey will provide a bibliography for further Study.

The rest of this article has been structured. Section II includes fundamental adhesion and locomotion for PWCR. In section III, for the purposes of inspection, the most symbolic applications of PWCR are presented by classification in the Kent application related scientific ds c fi elder. Finally, the conclusions are given in section IV

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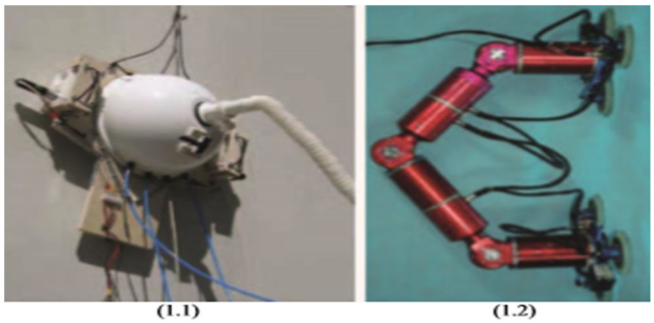


Fig. 1. Two types of pneumatic wall climbing robots: (1.1) CROMSCI use of negative pressure-load adhesion and wheel-driven space, and (1.2) W-Climbing robot vacuum suction cups and legged locomotion .

II. FUNDAMENTAL PRINCIPLES OF PNEUMATIC WALL CLIMBING ROBOT

PWCR can be classified through two major operational methods: A) Adhesion and B) Controls. These methods are present in many combinations, the most important of which will be highlighted in this section.

A. Adhesion Mechanism

1) Suction cups: A suction cup is an elastic and suction extensible object capsophyfrying partital vacuum, i.e. Ineffective surfaces are able to provide a larger weight-to-force ratio, to follow non-surfaces . SC has been divided into two main categories, depending on the generation of vacuum adhesion: A) Inactive: and B) active.

In the inactive suction, partial vacuum is obtained through the physical pressure of the cap against the desired surface. When physical pressure is exhausted, elastic material returns to its original winding shape. The duration of suction effect depends on the time the air takes to leak back into the cavity between the cup and the surface.

On the other hand, partial vacuum is achieved through the use of external vacuum generator in active SC. Air is sucked continuously with the adhesion cavity, resulting in a strong adhesion on the desired surface. This benefit controlled active SCs for use in the adhesive system.

Surface abnormalities and cracks reduce the operating efficiency of SC's SC, because they cause leakage in the vacuum seal, and therefore loss of adhesion force. A work around this problem is to equip PWCR with several suction cups so that if one cup is vacuum leakage then the rest can be compensated.

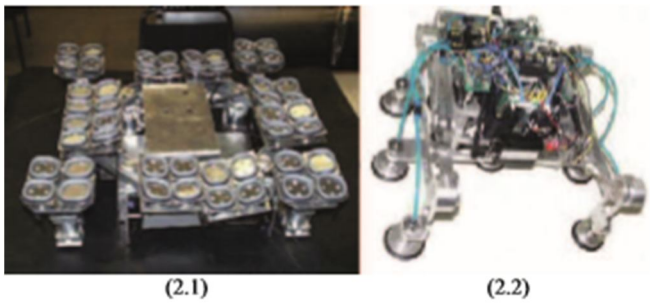


Fig. 2. SC-based Connection Guarences: Translational High Payload WCR MRWALLSPECT A Suction Cup Per Leg

A suction cup is usually used on each leg when the size requirements are small Usually three cups of suction cups are used when WCR uses leg-based locomotion to ensure adhesion in spite of crack and abnormality . More than two suction cups are usually used in large two-legged robots, which have high payloads, or medium-sized translucent emelvement PWCRs Should be able to go. To ensure adhesive cient adhesion of large transitional PWCR with high payload, the necessary SCs can reach an impressive high number . In addition, the feet of SCs are used in PWRs for additional adhesion forces.

2) Negative Pressure-Thrust: Negative pressure-thrust (NPT) is an adhesion method that has increased rapidly in WCR related applications. The adhesion mechanism serves as a scheduled cast without the need for a vacuum seal against the surface, instead a high speed rotor is used to remove the air between the robot wall and the bottom plate.

In this approach, successful aerodynamic charm on the target surface is obtained through the use of a vacuum impeller-based mechanism, which is connected to a vacuum motor (Fig. 3.). Due to the high speed rotation of the impeller, the wind the creates an

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aerodynamic vortex effect which causes the pressure to leave, an effect that is closer to the insenti fi tensenter impeller . In general, negative pressure leads to an aerodynamic attraction. Surface. It should be noted that for the maximum available attraction, the impeller should be selected with proper blade pro and take and dimensions, while using the appropriate motor type should be able to create high-speed rotation.

The advantage of this method is that no contact has to be done with the target surface, which provides an underlying nondestructive test (NDT) feature. Avoids the use of external pneumatic devices (such as whirlpool generators), and thus result in a more compact and autonomous design resulting from the overall concept. Bottom, the use of vacuum motors and additional equipment (sensor, motor controller etc.) is necessary, the complexity of the setup increases overall weight, dimensions and design complexity. In addition, in this case, the suction area is limited to the center part of the impeller system, which increases the different cultures to support large payloads due to continuous air leak from the external impeller sections.

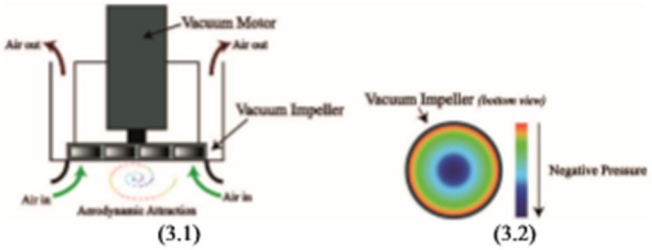


Fig. 3. Vacuum impact-based concept for aerodynamic attraction, Distribution of negative pressure on the scene below the impeller mechanism of the map (dark colors correspond to the large values of full negative pressure and strong attraction).

Large attraction force can be generated using more powerful motors or larger impeller dimensions, which increases the overall power consumption of the vortex robot, amplitude, weight and drag torque, thus affecting restrictions imposed on maximum payload

B. Locomotion Mechanism

1) Leg-based Locomotion: A common method for movement in SC-based PWCRs is the speed of the foot shown in Figure 4. This type of speed provides the ability to apply the required stevevise operation by SC, as well as several degrees of Freedom (DOF). Ability to avoid obstacle The loss of this locomotive strategy requires less speed and advanced control systems which are highly complex.



Fig. 4. Two types of leg-based PWCRs: (4.1) RAMR cut the WCR and (4.2) MRWALLSPECT quadrilateral robot.

An approach to simplifying the control problem of such a PWCR is a binomial design which is available in both DOFS and the system's overall Includes speed. The use of quadruple design enhances the complexity of the system, but provides more adhesion point to the surface, thus making it less susceptible to the potential adhesion loss of a suction cup.

2) Translational Locomotion: Translational National Locomotive refers to a strategy based on a gradual motion pattern. This kind of movement, though simple from the point of view, suffers from issues of size and speed. The use of PWCR is usually two frames in the trans locational locomotion, which can move forward in relation to one another. Each frame has several suction cups for surface adhesion, and in each of the alternate steps, each frame connects to the target surface because the other frame moves to its new position. This speed strategy is inspired by the sequential speed pattern of a caterpillar.

3) Wheel-Driven Motion: Wheel-driven engines are only implemented in cases of NPT-based PWCR because their continuous adhesion force application allows them for their constant speed, although they suffer from avoiding the obstruction and sliding when not properly controlled. Several different implementations of wheel-driven movements have been presented in the related bibliography.

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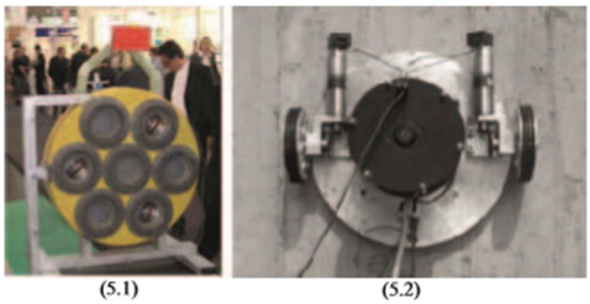


Fig. 5. Wheel driven NPT PWCRs: (5.1) CROMSCI three Omni-directional wheel robots , and (5.2) Alicia two wheel-based PWCR.

III. APPLICATIONS OF PNEUMATIC WALL-CLIMBING ROBOTS FOR INSPECTION PURPOSES

A. Inspection of Construction Applications

One of the most common inspection applications of PWRR is the examination of infrastructure, e.g. To detect irregularities of buildings and bridges, cracks and structures, which are performed manually when it becomes a very time consuming and dangerous task. In addition, this application area has been popular due to the widespread compatibility of targeted surfaces of PWCRs, because buildings are usually constructed from non-ferromagnetic materials.

Bridge climbing robot, shown in Figure 6.1. , the bridge was designed to inspect the crack in the walls and large support columns. In this concept and through high-de-images NAT images, taken with on-board camera, and image processing is transmitted in real time through a tele-communication link to the computer, state of the structure and over -All health can be analyzed. Alicia 1 (Fig. 6.2), Alicia 2 (Fig. 5.2) and Alicia 3 (Fig. 6.9) to detect cracks through the use of large concrete walls, such as highway bridges and dams, and ultrasonic heads. Was designed for. PWCR presented in the picture. 6.3 A camera was developed to visualize cracks in concrete structures using. Image of Camera Feedback from Robot was processed at the grassroots level. ROBIN (Figure 6.4) was designed to carry cameras and relevant sensor equipment for large infrastructure, such as bridges, buildings, aircraft and ship inspection. Double-cavity climbing robot (Figure 6.5) glass-wall inspection was developed keeping in mind. Ninja-I and II (Fig. 6.6), Robbug II (Fig. 6.7) and ROM2 2 (Figure 6.8) were designed to inspect buildings and other infrastructure, each one Special on Different Scanning Parts and materials Wall inspection is also a popular application performed by the same PWCR found in related bibliography (Figure 6.10) . In addition, CROMSCI (Fig. 1.1) was designed for non-destructive testing of large concrete walls (NDT), e.g. Dam and bridge.

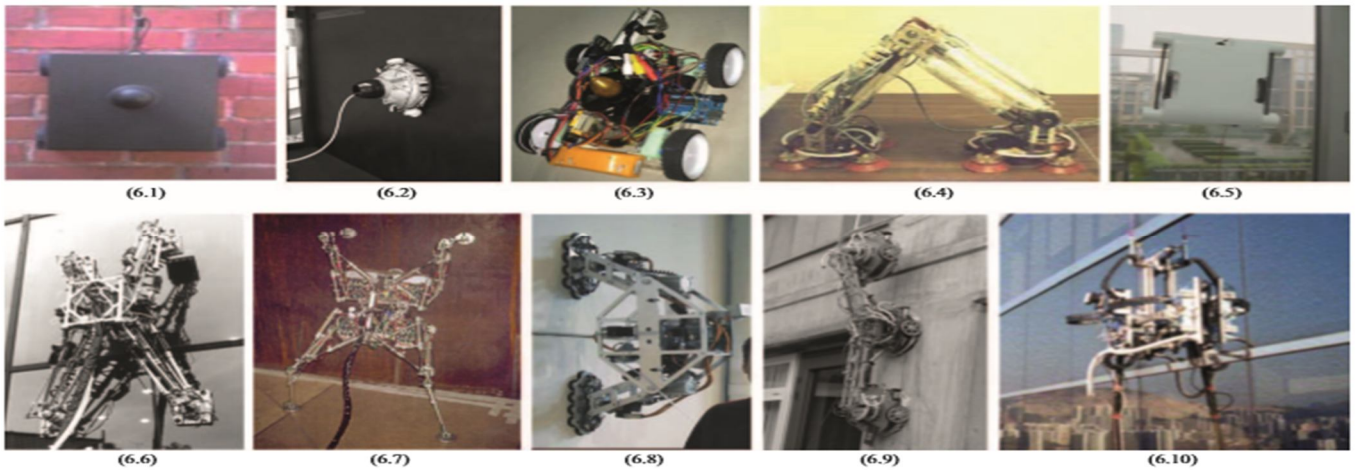


Fig. 6. Inspection of construction applications: (6.1) Bridge inspector , (6.2) Alicia 1 , (6.3) Inspector of Concrete Crack , (6.4) Robin (6.5) Double-growth Robot II , (6.8) ROMA2 , (6.9) Alicia 3 , And (6.10) Glass-inspector of glass-walls.

The pylons, while the hole inside the concrete is equipped with an impulse radar and has a high-resolution camera to detect a crack of 0.2 mm width. In the end, W-Climbing robot (Fig. 1.2) and SIRIUS were designed for general inspection of construction and infrastructure.

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B. Inspection of Industrial Infrastructures

Inspection of the interior of the tank is always considered as a separate, cult work, because it can contain toxic substances or can be located in areas to reach the cult manually. under the ground. In order to solve this issue, several PWCRs have been proposed to do this kind of inspection routine.

Specially, VIRIV (Fig. 7.1) For visual inspection, the weld was developed inside the storage tanks and for important spot inspection. MRWALLSPECT II (Figure 2.2) and MRWALLSPECT III (Figure 4.2) both were designed for external ultrasonic inspection of oil or gas tanks. The ROBICEN I, II and III, shown in Figure 7.2, were developed to inspect the leakage of steam and water in monitoring of nuclear contamination and dangerous environments , . Survey (Figure 7.4) was developed and was developed to measure the level of corrosion for example. Industrial tanks or other metal materials, while the robots (Fig. 7.3) and (Figure 7.5) were displayed which were designed for general structural inspection of the hazardous environment, e.g. Nuclear Plants and Toxic Storage Tanks

C. Aircraft Inspection

PWCR has also been introduced in the aviation for inspection of the outer hall of the airways. Multifunction auto

In order to detect cracks and other abnormalities in the outer surface of the plane, the mate crawling system MACS (Figure 8.1) was developed to inspect large vessels through ultrasonic sensors. Similarly, the NDT robot was displayed in Figure 8.2. It was developed at the London South Bank University for inspection of aircraft's wings and torso. Due to its abandoned structural implementation and active vacuum suction cups, it was able to carry a payload of up to 18 kilograms. Fig. 8.3 and 8.4 Lufthansa's aircraft inspection robot displays MORFI, which was equipped with NDT sensory equipment to assure the health of aircraft fuselage.

D. PWCRs for General Inspection Purposes

In PWCR, for normal inspection purposes, RAMR1 (Figure 4.1) was introduced in for inspection and assessment of dangerous environments, such as buildings or con ards ned spaces of biological hazards and hostile situations inside for.

Micro Aerial Vehicle (MAV) (Picture (9.1) There is a hybrid development with both UAV and wall-climbing facilities for inspection of wind turbines, using the four rotors, the robot can flub the wind blade. The Siezwell 'A' Duct Inspection Tool (SADIE) (Figure 9.2) was developed to inspect the weld in a tight and dangerous environment, where the turbine encloses itself and inspects the surface. A Are inaccessible through the use of humans. Ultrasonic scanning to analyze the weld quality and position.

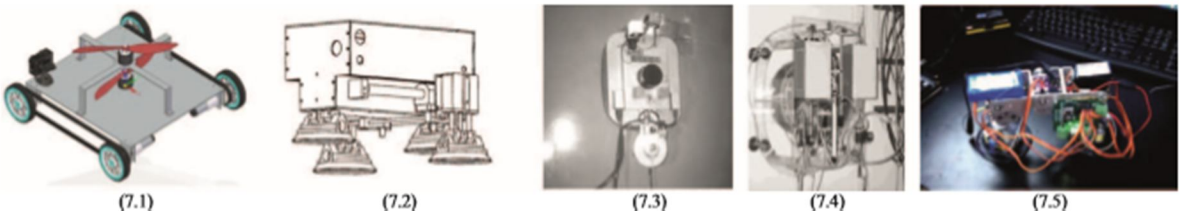


Fig. 7. Inspection of the industrial infrastructure: (7.1) VIRIV , (7.2) Robicon , (7.3) General Inspection Robot , (7.4) Survey , and (7.5) Small Ascent Atomic Energy Robot for intelligent inspection of plants

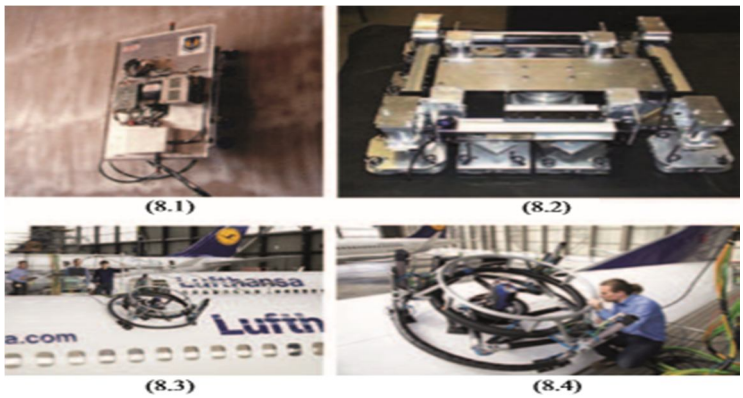


Fig. 8. Aircraft inspection PWCRs: (8.1) MACS (8.2) NDT PWCR (8.3) and (8.4)

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Which was designed primarily for risk assessment of large infrastructure in relation to seismic risk, while low cost pro enable was taken to enable its commercial availability.

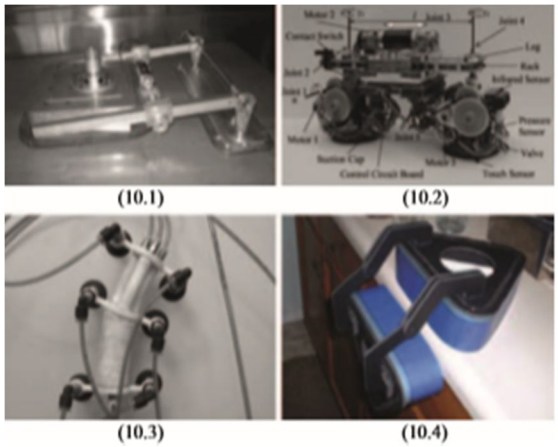


(9.1) (9.2)

Fig. 9. Other inspection applications: (9.1) MAV [32], (9.2) SADIE

In addition, after the concept of inspection as a target application, many PWCRs have also been developed, although they were not equipped with the necessary equipment.

The PWCR was developed in the Harbin Institute of Technology (Figure 10.1) which was prepared as a platform for inspection instruments of rescue missions along with construction applications. Walkman-I (Figure 10.3) was a small, lightweight PWCR and its inspection benefit, which lies in its ability to reach inaccessible places where the manual Inspection is difficult or impossible. Similarly, two robots (Figure 10.2 and 10.4) were developed as normal platforms for inspection purposes.



(10.1) (10.2)

(10.3) (10.4)

Fig. 10. Generic Inspection PWCRs: (10.1) [38], (10.1) WALKMAN-I [18], (10.3)

IV. MODEL AND CALCULATION



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We have tested our project pneumatic wall climbing robot and we have obtained following results:-

1) *Speed of Robot:* On testing our project we obtain the speed of robot which comes out to be 0.10 m/s.
2) *Payload carrying Capacity:* Assuming eight suction cups, each of diameter 3.5 cm the payload is calculated as follow

We use an equation

d=1.12*(m*S/Pu*n*μ) ½ where,

m- Mass of the robot, d- Diameter of suction cup, Pu- Pressure exerted by suction cup

We know m = 2kg, d = 3.5cm, n = 8, μ = 0.5 and S = 4 for vertical and 2 for horizontal, then, by substituting these values in above equation. We get Pu = 0.182 bar

Pu = 0.182 x .5 = 0. 091kg /cm2. This is pressure created by suction cup. Now, if A is the area of the surface covered by the cup and if we have 4 active suction cup of dia. 3.5cm, then the mass carried by single suction cup = A x Pu = 9.621 x 0.091 = 0.875 kg. Hence the total payload together by four suction cups will be 4 x .875 = 3.2 kg.

3) *Holding Force:* Here, holding force required to hold the robot against the wall is calculated first. Formula for theoretical holding force is given by

FH= (m/μ) x (g + a) x S

Where,

m = mass of robot including mass to be carried,

μ = coefficient of friction

g = acceleration due to gravity

a = acceleration of robot

S = factor of safety

Now by previous result we take m=5 kg, μ=0.5, g=9.81 m/s^2, a=.1 m/s^2, S = 4 for vertical and 2 for horizontal,

On putting these value , we get holding force=396.4N

4) *Breakaway force (FA):* If several suction grippers are used simultaneously in a vacuum application, the result of the theoretical holding force FH calculation must be divided by the number of active suction grippers. In our case, we are using four suction cup on each limb of robot which will be sharing the load of robot at the moment,

Therefore

FA=FH/N

Now breakaway force 396.4/4=99.1N

V. CONCLUSION

A survey was conducted on Pneumatic Wall-Climbing Robot (PWCRs) for inspection in this article. The basic principles of adhesion and locomotion for PWCRs have been discussed and mainly focused on inspection applications of PWCRs. These applications had been divided into four categories, A) construction, b) industrial infrastructure, c) aircraft and other applications, the most important detailed overview of Peed blusiar were four aid related bibliography.

A review of the inspection applications of PWCRs has shown that robots have a growing tendency for structural inspection. This growing interest is assessing the promising results of PWCR's current technological development, while continuous research on this subject will help in maintaining the health of the infrastructure at a higher level.

A large number of PWCRs have been developed and specializing in inspection of infrastructure, this survey has also found the ability of research and development on PWCR for challenging applications of aircraft inspection through modern design techniques and advanced.

Control formations to overcome the challenges of the curved overall surfaces of the plane. Overall, the results of the survey can be summarized in the following table I.

Adhesion	Locomotion	Pros	Cons
Suction Cups	Leg-based	Good obstacle avoidance	Slow
Suction Cups	Translational	Easy control	Slow
NPT	Wheel-based	Continuous motion	Complex control

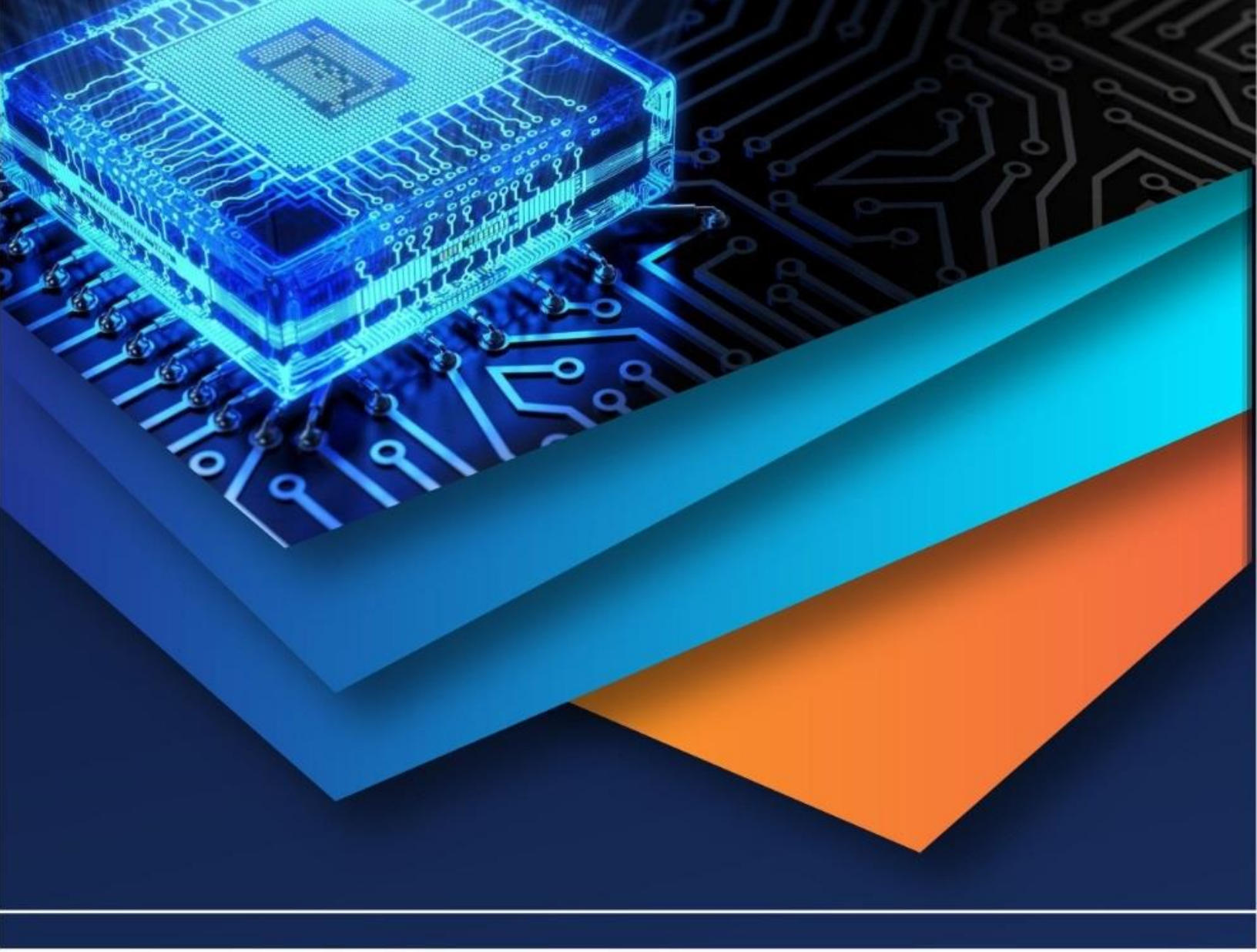
Table-1

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REFERENCES

[1] M. Armada, P. G. de Santos, M. A. Jimenez, and M. Prieto. Application of CLAWAR Machines. Int. J. Rob. Res., 22(3-4):251–264, 2003.
[2] Baeksuk Chu, Kyungmo Jung, Chang Soo Han, and Daehie Hong. A survey of climbing robots: Locomotion and adhesion. Int. J. Precis. Eng. Manuf., 11(4):633–647, 2010.
[3] Yu Yoshida and Shugen Ma. Design of a Wall-Climbing Robot with Passive Suction Cups. 2010 IEEE Int. Conf. Robot. Biomimetics, pages 1513–1518, 2010.
[4] Jun Li. Wall climbing robot based on negative pressure-thrust suction method. 2008 IEEE Int. Conf. Mechatronics Autom., pages 604–609, 2008.
[5] Da Guan, Lei Yan, Yibo Yang, and Wenfu Xu. A Small Climbing Robot for the Intelligent Inspection of Nuclear Power Plants. 4th IEEE Int. Conf. Inf. Sci. Technol., 2014.
[6] Avello A. Briones L. Serna, M. A. and P Bustamante. ROBICEN: A Pneumatic Climbing Robot for Inspection of Pipes and Tanks. Lecture Notes in Control and Information Sciences, Vol. 232, pages 325–334, 1998.
[7] N Elkmann, Torsten Felsch, Mario Sack, J. Saenz, and J. Hortig. Innovative service robot systems for facade cleaning of difficult-toaccess areas. IEEE/RSJ Int. Conf. Intell. Robot. Syst., 1(October):756– 762, 2002.
[8] Dong Sun, Jian Zhu, Chiming Lai, and S.K. Tso. A visual sensing application to a climbing cleaning robot on the glass surface. Mechatronics, 14(10):1089–1104, 2004.

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