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City-Climbers at Work

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Abstract— **The video presents recent progress of the wall-climbing robot project at the City College of New York. The robots are named as City-Climbers which adopt a novel adhesive mechanism based on aerodynamic attraction to achieve good balance between strong adhesion force and high mobility. The video demonstrates that the City-Climber robots can operate on virtually any kind of smooth or rough surfaces and have the capabilities to move on the ground, climb walls, and transit between them. The modular design achieves both fast motion of each module on planar surfaces and smooth transition between the surfaces by a set of two modules. The video also displays the Fluent simulation results of the aerodynamic attraction with the aim to optimize the design. DSP-based control system is introduced which enables the robot to operate both manually and autonomously.**

I Video Summary

It has been a long-time dream to develop miniature climbing robots with the ability to climb walls, walk on ceilings, and transit between different surfaces, thus transforming the present 2D world of mobile rovers into a new 3D universe. A multi-disciplinary robotics team at the City College of New York (CCNY) has developed many prototypes of mobile climbing robot [1-3], which makes several steps closer to realize this dream. The robots were named as City-Climber which overcome the limitations of the existing technologies, and outperform them in terms of robot capability, modularity, and intelligence. Unlike the traditional climbing robots using magnetic devices [4-6], vacuum suction techniques [7-11, 14], and some recent novel climbing robots of the vortex-climber type [12] and the robots inspired by the gecko foot [13], the City-Climber robots use aerodynamic attraction which achieves a good balance between strong adhesion force and high mobility. Since the City-Climber robots don't require perfect sealing as the vacuum suction technique does, the robots can move on essentially any kind of smooth or rough surfaces such as brick, concrete, wood, glass, stucco, plaster, gypsum board, and metal.

The potential applications of the City-Climber robots include: inspection of high-rise buildings, tool/weapon delivery, search and rescue operations, reconnaissance and surveillance, intelligent gathering in hostile situations, and assistance in fire-fighting, etc.

The video displays project progress and technical achievements of the City-Climber robots outlined as follows.

1) *The evolution of the City-Climber prototypes, from the proof-of-concept design to the current version*

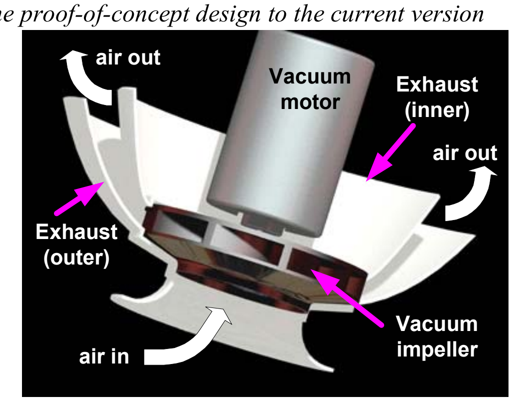

Fig. 1 Vacuum rotor package to generate aerodynamic attraction

2) *The animation illustrating the novel adhesive mechanism based on aerodynamic attraction as shown in Fig. 1.*

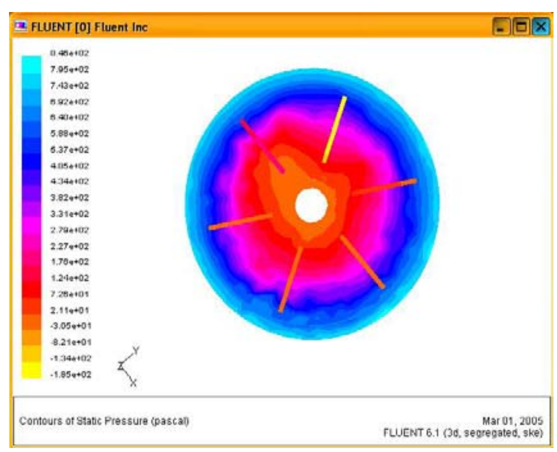

Fig. 2. Aerodynamic simulation with Fluent 6.1 software which shows the pressure distribution inside the rotor cylinder.

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3) *The Computational Fluid Dynamics (CFD) simulation results of the aerodynamic behavior as shown in Fig. 2.*

4) *The experimental test for suction force*

5) *DSP-based control system which enables the semi-autonomous operation of City-Climber robots*

6) *The snapshots on prototyping and fabrication*

7) *The video illustrating the main areas of functionality of the City-Climber prototypes, such as operation on the ground, on various wall surfaces (glass wall, brick wall, etc.), inverted operation on ceilings, and smooth ground-to-wall transition, etc.*

Fig. 3 The City-Climber V1 clings to a ceiling.

Fig. 4 City-Climber V2 approaching a window on brick wall; while transmitting real-time video for inspection purpose

8) *The animation showing the transition of the two module City-Climber V3.2*

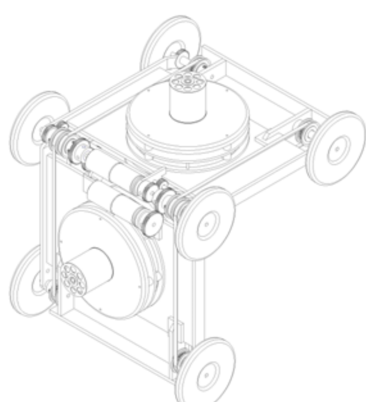

Fig. 5 Two module version of City-Climber V3.2

II Conclusion and Future Work

The video highlights some accomplishment of CCNY robotics team in developing novel wall-climbing robots. The future work is to optimize the adhesive mechanism to further increase adhesion force and robot payload, and to improve the modularity and transition mechanism to allow the robot re-configure its shape to adapt to different missions. Other directions are to increase the robot intelligence by adding new sensors, improving on-board processing unit, and developing software algorithms for autonomous navigation.

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