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Development of a Throw & Collect Type Rescue Inspector

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***Abstract*— In order to search survivors in half-collapsed buildings at disastrous sites, the authors have developed the Throw & Collect Rescue Inspector. It is composed of a throwing and a drawing mechanisms and a child machine equipped with camera. The parent robot is inserted to the site and starts the inspection of the area. If an obstacle is in the way, it throws out a child machine with its magnetic brake pneumatic cylinder, and the inspection can be performed beyond the obstacle while the child machine is drawn back. This report shows the details of the structure of the robot.**

I. Introduction

Terrorism and natural disasters are frequently occurring in present days, and searching for survivors trapped inside half collapsed buildings has become an essential and a dangerous task for rescuers. The danger upon a rescuer can be minimized if special devices or robots are used in such operations. These robots are required to be low weighted and small sized, in order to be easily handled throughout the site. However, downsizing generally hinders its traversing performance over severe ground conditions. Not only being small, it is necessary to obtain high performance to inspect the areas by traversing over debris.

As one possible solution, we have developed a mobile inspector, which uses a method consisted of efficient rolling on the flat combined with jumping over big obstacles [1]. This robot, which we called the Leg-in-Rotor, has 30 cm of diameter, 50 cm of length, and weights around 2 kg. Rolling uses electric power whereas jumping uses compressed air (fluid power). In most solutions, electromechanical power is used for the jump as in [2], or simple pneumatic drives come out handy, as in [3], [4], but little performance in rubble environments can be assured. Reference [1] shows the structure of the robot and the improvement of its pneumatic drive, and the robot is now capable of jumping over obstacles of 1 m height while rolling in surfaces (Fig.1).

Fig. 1. Performance of Leg-in-Rotor-V: roll and jump on debris and jump again after recovering its posture

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However, in spite of the great efficiency of the jump, it can be hindered from the ground condition: either when it is too severe, or too soft. Furthermore, in order to improve even more its jumping performance, it is necessary to use larger valves, or to use valves in parallel [1], which is undesired to maintain the small size of the robot.

Therefore, a new method is proposed to clear the problems above mentioned. This method (Fig.2) consists of the following performance: ①the parent robot is inserted into the site, ②searches in until it comes across an obstacle, ③then it throws out a child machine over this obstacle, ④and finally performs the search beyond the obstacle while drawing back the child machine. With this method, the ground condition does not affect the throw, which can be done many times in several directions.

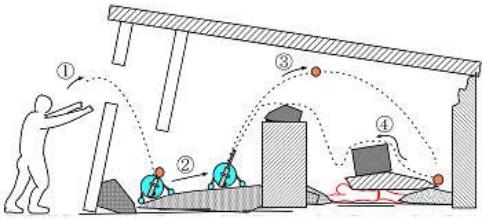

Fig. 2. Concept of the throw & collect rescue inspector

In order to realize such method, a parent robot needs a throwing mechanism, a collecting mechanism, and a child machine. Each of these functions will be detailed in the next sections.

II. Parent Robot

The parent robot can be designed with different shapes. It is defined by its access methodology into the building, and it can be divided into two major categories: an active parent robot (Fig.3a), which is operated to move through the area; and a passive parent robot (Fig.3b), which is inserted into the site and held by the rescuer.

Fig. 3. Types of parent robots: active mobile inspector (a) and passive telescopic rod inspector (b)

Additionally, in a situation that needs to throw the child machine into the site from outside the building, the rescuer may choose to use only the throwing mechanism.

III. The Throwing Mechanism

For the throwing mechanism, we decided to use a pneumatic cylinder to launch the child machine, which has a great output power and easy pressure sources can be used, such as Dry-Ice Power Cell [5]. However, it could only throw the child machine 1 m high, since internal pressure fall of the cylinder occurs when moving light loads. As solution, combining the cylinder with elastic energy of a coil, or a servo-motored mechanical trigger can be used, but those increase the number of actuators.

So instead, we proposed a new pneumatic actuator, the magnetic brake cylinder (Fig.4), which uses a magnet as a trigger. The magnet, placed inside the lower part of the cylinder, holds down the piston-rod until the pressure is very high, and internal pressure fall of the cylinder can be avoided.

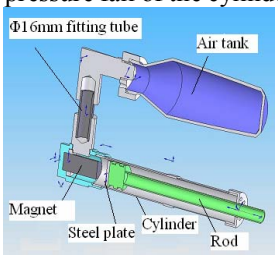

Fig. 4. The throwing mechanism: Magnetic Brake Pneumatic Cylinder

In order to control the throwing height, after several options, we have decided to change the initial area of the piston, by dividing the lower part of the cylinder into two chambers [6]. Injecting air only into the main chamber, the piston area is small, and the necessary pressure to detach the piston from the initial position is higher (due to the magnet's attractive force). Therefore, the throw is as high as possible. For lower throws, air is injected into the secondary chamber in an interval of time after injecting into the main chamber. At this instant, the piston area becomes large and the piston is detached with lower pressure from its initial position, and the throw becomes lower.

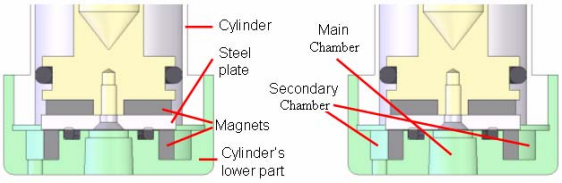

Fig. 5. Structured aimed to control the throwing height

IV. The Collecting Mechanism

In order to draw back the child machine, a reel or similar mechanisms can be used, but those would require using large actuators. To simplify, we have designed a mechanism composed of a taper case and a pinch-roller (Fig.6).

After performing the throw, the pinch-roller pinches the tube, and the roller is driven by a small motor. Using the tube's elasticity, it is pushed into the taper case and it winds up by itself.

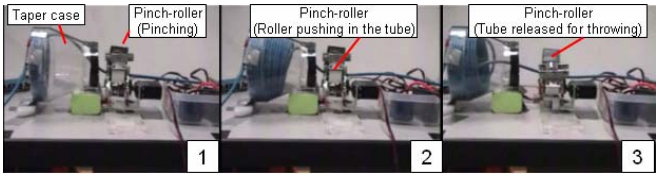

Fig. 6. The drawing mechanism: pinch-roller and taper case

V. The Child Machine

The child machine equips camera and other sensors for the search, it should be light and it must endure impact when landing from a throw.

We have developed two types of child machines: a passive, which has a one degree of freedom gimbals to maintain the cameras posture (Fig.7a), and an active child machine [7], which is equipped with active and passive wheels and a magnetic brake cylinder in order to evade from stuck position and to inspect further (Fig.7b).

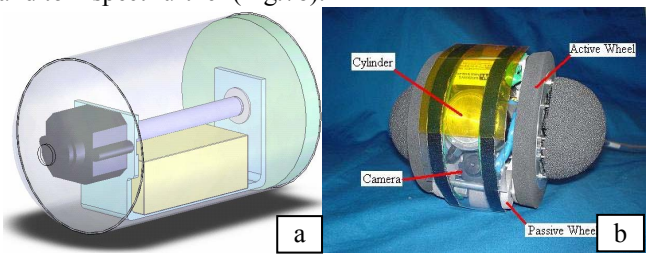

Fig. 7. Developed child machines: passive (a) and active (b)

VI. Conclusion

This report has demonstrated the development of the Throw & Collect Type Rescue Inspector, and the details of its mechanisms. In order to enhance its searching ability, the next steps of this research are as follows: i) propose a designing method of the magnetic brake cylinder, ii) propose a new design of the parent robot; iii) improve the functions of the child machine.

References

[1] H. Tsukagoshi, M. Sasaki, A. Kitagawa, and T. Tanaka, "Design of a higher jumping rescue robot with the optimized pneumatic drive," in *Proceedings of the 2005 IEEE International Conference on Robotics and Automation, Barcelona, Spain, April 2005*, pp 1288-1295.

[2] A. Drenner, *et al.*, "Communication and mobility enhancements to the scout robot," in *Proceedings of the 2002 IEEE/RSJ International Conference on Intelligent Robots and System, Lausanne, Switzerland, October 2002* [Online]. Available: http://distrob.cs.umn.edu/publications.php

[3] M. H. Raibert, "Legged robots that balance," *MIT Press*, 1986.

[4] Yamafuji, and Mitsuya, "Development and motion control of a jumping mobile robot," *JSME*, 57-537 (in Japanese), 1616/1620, 1991.

[5] A. Kitagawa, H. Tsukagoshi, H. Wu, and S. Park, "A novel pneumatic power source using solid-gas phase transition," *Conference of Japan Fluid Power System Society*, Autumn 2003, pp 123-126 (in Japanese).

[6] E. Watari, H. Tsukagoshi, and A. Kitagawa, "Development of a throw & collect type rescue inspector – 6th report: control of the throwing distance by a magnetic brake cylinder," *SICE-ICASE International Joint Conference 2006 (SICE-ICCAS 2006)*, SA08-4 (DVD-ROM).

[7] H. Tsukagoshi, D. Kimura, E. Watari, and A. Kitagawa, "Throw & collect type victim searching robot – development of child machine," *SICE System Integraton Division Annual Conference*, SI2005, Paper Digests 1J4-2 (in Japanese), December 2005.