CONTROL OF THE MULTI-TRACK TYPE ROBOT INSPIRED FROM ANTENNAE OF A CENTIPEDE*

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This paper proposes a method to control a multi-track type robot developed for reconnaissance missions. A centipede decides body motion using antennae on its head instead of using eyes. Inspired from that, we imitated the antennae using 3 IR sensors attached in front of the robot. Based on the information got from the sensors the robot decides next behavior automatically. By the proposed control method, the robot was controlled effectively in various environments. The control method and experiment results are mentioned in this paper.

1. Introduction

Recently, there are many approaches to a reconnaissance robot which issue is improving mobility. We are developing a small, light and portable reconnaissance robot for soldiers. To improve mobility, we suggested an active multi-joint track type robot which has low height but long body. Already there are many approaches to this type robot, but there are some problems in that. Most of these type robots need many operators to control or they take a quite long time to control each joint for overcoming an obstacle. To solve these problems, we tried to find some idea from a centipede because a centipede is very good at controlling its many joints (muscles). Our robot has some similar point to a centipede, which is active joint and long body. A centipede has very bad sightseeing therefore it mainly depends on its antennae. Using the antennae, a centipede knows about circumstance and decides their movement. If it meets obstacles, it climbs up and if it reaches on the top, it climbs down. Collecting information from antennae and organizing climb up or down behaviors, a centipede can go in a various outdoor environments. In this paper, we focus on these points and suggest an algorithm for control of a multi active joints robot.

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2. Mechanical System

Figure 1 shows entire configuration of the robot. This system has one brain module and four connecting modules. The brain module contains a battery and controller. Between modules, there are motors which are used to raise or bend the body, but there is no consideration about direction in this version. Each track has one motor, so it uses 10 motors for track. More specific information can be seen on Table1.

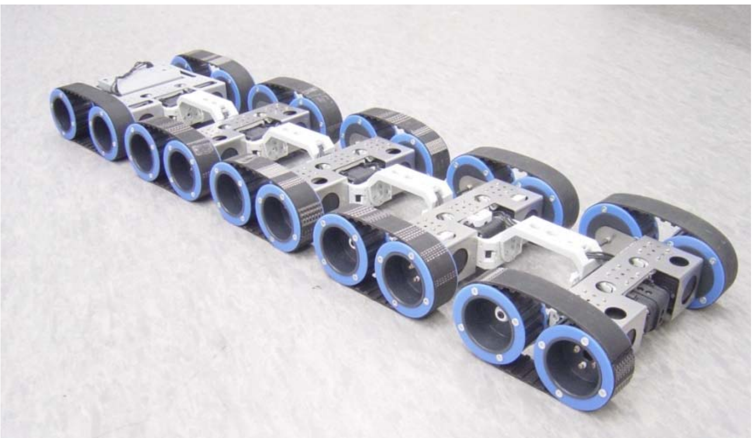


Figure 1. Configuration of the robot

Table 1. The specification of the robot.

	Length	Width	Height	Weight
Brain Module	150mm	200mm	65mm	1.20kg
Connecting Module	125mm	200mm	65mm	0.64kg
Entire robot	750mm	200mm	65mm	3.76kg

3. Up / Down Climbing Decision

To control the multi-track type robot effectively, we got an idea from the movement of a centipede. When a centipede overcome obstacles, using its antennae it checks an environment and if meets obstacles, it raises its body and climb up constantly until get to the top. If it reaches the top, then it bends its body and climb down from the obstacles. Although a centipede has many active joints (muscles), it can overcome obstacles without difficulties. A centipede recognizes an environment using its antennae and makes its body into proper shape to the environment

Inspired from recognition system of a centipede using antennae, we imitated the function of antennae using IR sensors. We installed three IR sensors on the top, front and below of the first connecting module. Through these sensors, the robot can know about the environment like an antenna of a centipede. We analyzed the motion of a centipede and drew flow chart to operate the robot.

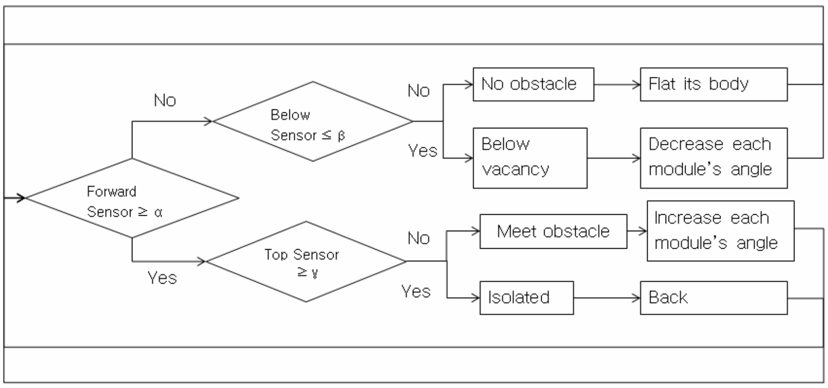
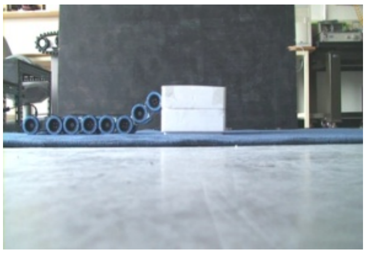
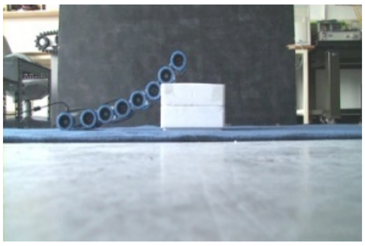


Figure 2. Flow chart of the robot motion (α, β, γ are IR sensor values and the values are inverse proportion to distance)

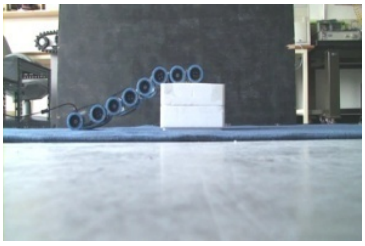
The front sensor constantly checks whether obstacles or not in front of the robot. This decision has the first priority so in any condition that mixed with other condition if the robot meets an obstacle, it raises its head. Using the below sensor the robot can check vacant space under the robot. If there is vacant space under the robot, it judges that it needs to bend the body. This circumstance occurs when the robot climbs down the obstacle from the top. After it finishes overcoming, it flats the body. This process repeated continuously. This decision system is simple, powerful and robust, so in various environments, for example stairs, low wall, gravely field and on logs, we can use this method. For your more understanding, we explain the algorithm, using one example.



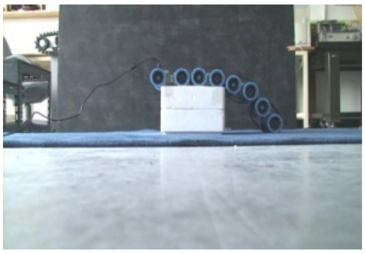
1 - When the robot meet an obstacle, its front sensor become more than α, so it raises its body



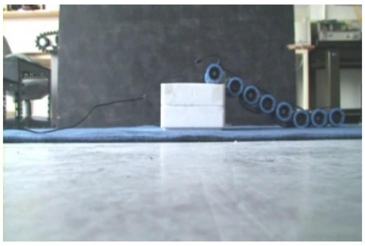
2 - If the robot reach the top, there is no obstacle and its below sensor become more than β



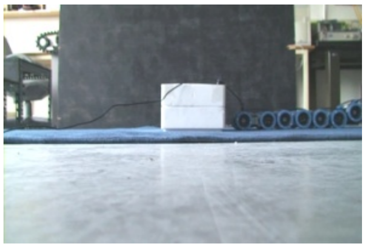
3 - So the robot bend its body



4 - On the top, the robot flats its body and it bends again and down the obstacle.



5 – If the robot meets the bottom it raises its body



6 – When the robot end overcome, it flats its body

Figure3. Detail explanation about one example

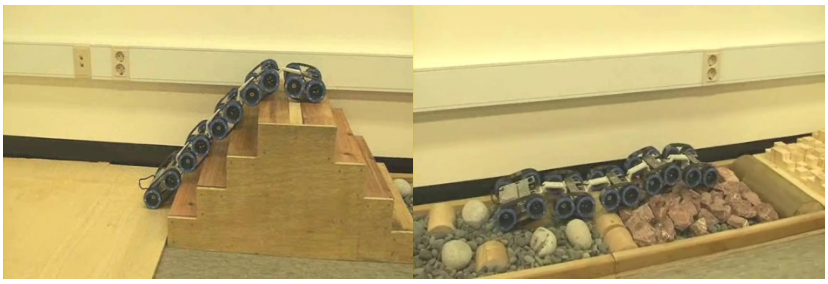
4. Experimental Results

In this experiment, we do not consider turn of the robot and use only go/back. We did an experiment on stairs and square-shape obstacles. Target obstacles are various stairs and high-height squared obstacles because we think stairs and high- height squared obstacle are one of the most difficult obstacles to overcome. We also did an experiment including on a gravely field, log and rugged terrain. Table 1 shows an experiment result and figure 4 shows some test environments and obstacles

Table 2. Performance of the robot

Parameter	Evaluation
Maximal velocity	15cm/sec
Performance on stairs	Good (45degree slope, 9cm height stairs)
Performance on logs	Good (20cm diameter)
Performance on rocks of rubble	Good
Maximal height of vertical wall climbed	36cm (48% of robot’s length or 550% of robot’s height)

Figure4. Testing in different challenging environments



5. Conclusion

We developed a small and portable reconnaissance robot and to control this robot effectively we suggest a control method inspired from a centipede. Using this control method, the operator can control many active joints effectively without worrying about variation of environment and the robot can overcome obstacles automatically in its range. Therefore using proposed control method, the robot can easily negotiate in the various environments like a centipede.

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References

1. G. Gnosik, J. Borenstein and M.G. Hansen, “Serpentine Robots for Industrial Inspection and Surveillance.” *Industrial Robotics – Programming, Simulation and Applications*, 633-662 (2007).
2. A. Masayuki, T. Takayama and S. Hirose, “Development of Souryu-Ⅲ: Connected Crawler Vehicle for Inspection inside Narrow and Winding Spaces”, *Proceedings of 2004 IEEE/RSJ International Conference on Intelligent Robots and Systems*, September 28 – October 2, 2004, Sendai, Japan (2004).
3. H. Benjamin Brown, Jr., J. Michael Vande Weghe, Curt A. Bererton, and K. Khosla, “Millibot Trains for Enhanced Mobility”, *NIEEE/ASME transactions on mechatronics,* **VOL. 7,** NO. 4, December 2002 (2002).
4. S. Hirose, M. Mori, “Biologically Inspired Snake-like Robots”, p*roceedings of the 2004 IEEE International Conference on Robotics*

and Biomimetics, August 22 - 26, 2004, Shenyang, China(2004)

5. T. Kamegawa, T. Yamasaki, H. Igarashi and F. Matsuno, "Development of The Snake-like Rescue Robot KOHGA", *Proceedings of the 2004 IEEE International Conference on Robotlcs & Automation*, New Orleans, LA April 2004(2004)
6. H.Kimura, S, Hirose, "Development of Genbu : Active wheel passive joint articulated mobile robot", *Proceedings of the 2002 IEEE/RSJ International Conference on Intelligent Robots and Systems* EPFL, Lausanne, Switzerland, October 2002(2002)
7. K.-U. Scholl, V. Kepplin, K. Berns, R. Dillmann, "Controlling a Multijoint Robot for Autonomous Sewer Inspection", *Proceedings of the 2000 IEEE lntemational Conference on Robotics & Automation,* San Francisco, CANADA April 2000(2000)
8. S.Hirose, E.F.Fukushima, R.Damoto and H.Nakamoto, "Design of Terrain Adaptive Versatile Crawler Vehicle HELIOS-Ⅳ", *Proceedings of the 2001 IEEE/RSJ International Conference on Intelligent Robots and Systems*, Maui, Hawaii, USA, Oct.29-Nov.03,2001(2001)
9. T.Takayama, S.Hirose, "Development of Souryu-Ⅰ: Connected Crawler Vehicle for Inspection of Narrow and Winding Space", *26th Annual Conference of the IEEE Industrial Electronics Society, IECON 2000***,** **vol.1**,143-148.(2000)