A Development of Home Mess-Cleanup Robot with Entertainment Function

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Abstract: The vacuum-cleaner had made the burden of house chore lighten but the operation labour of a vacuum-cleaner had been so severe. Recently, the cleaning robot was producted to perfectly solve the cleaning labour of a house but it also was not successful because it still had a problem of mess-cleaning, which is the clean-up of big trash and the arrangement of newspapers, clothes, etc. The cleaning robot is to just vacuum dust and small trash and has no function to arrange and take away before the automatic vacuum-cleaning. For this reason, the market for the cleaning robot is not yet built up. So, we need a design method and technological algorithm of new automatic machine to solve the problem of mess-cleanup in house. In this paper, a Home Mess-Cleanup Robot(HMR), which has a practical function of the automatic mess-cleanup, is developed.

It need functions of agile automatic navigation, novel manipulation system for mess-cleanup. The automatic navigation system has to be controlled for the full scanning of living room, to recognize the absolute position and orientation of the self, the precise tracking of the desired path, and to distinguish the mess object to clean-up from obstacle object to just avoid. The manipulation system, which is not needed in the vacuum-cleaning robot, must have the functions, how to distinguish big trash to clean from mess objects to arrange, how to grasp in according to the form of mess objects, how to move to the destination in according to mess objects and arrange them. Then, it should be an intelligent system so that the mess cleaning task can be autonomously performed in a wide variety of situations and environments. It need to also has the entertainment functions for the good communication between the human and HMR. Therefore, the Home Mess-cleanup Robot with Entertainmental Human Interface is developed in this paper. Finally, the good performance of the designed machine, HMR'04, is confirmed through the results of the mess clean-up and arrangement.

Keywords: Home Mess-Cleanup Robot, The Automatic Navigation, Object Recognition, Entertainmental Human Interface

1. INTRODUCTION

The current robot requires the advanced technology, such as soft computing, human-friendly interface, interaction technique, speech recognition, object recognition etc., unlike the industrial robot in those days. RT(Robot Technology) is including these advanced techniques, and is full of promise in 21th century as IT(Information Technology), BT(Bio Technology) and NT(Nano Technology). Especially, Home Service Robot, a kind of personal robot for work, amusement and education of home, are world-widely studied in these days. A product of home service robot is the cleaning robot. The cleaning robot is an electric home appliance, which was developed from the wheel-based mobile robot in the same modification method as a vehicle robot of factory automation and a guidance robot.

The vacuum-cleaner had been developed in 1950's to help the manual cleaning of a house, which had been most important in house chore. It had made the burden of house chore lighten but the operation labour of a vacuum-cleaner had been so severe. Recently, the cleaning robot was producted to perfectly solve the cleaning labour of a house but it also was not successful because it still had a problem of mess-cleaning, which is the clean-up of big trash and the arrangement of newspapers, clothes, etc. The cleaning robot is to just vacuum dust and small trash and has no function to arrange and take away before the automatic vacuum-cleaning. For this reason, the market for the cleaning robot is not yet built up. So, we need a design method and technological algorithm of new automatic machine to solve the problem of mess-cleanup in

house. In this paper, a Home Mess-Cleanup Robot(HMR), which has a practical function of the automatic mess-cleanup, is developed.

Home Mess-cleanup Robot is not work in the fixed task such as industrial robot but have to work in much more flexible and various environments than the vacuum-cleaning robot. It need functions of agile automatic navigation, noble manipulation system for mess-cleanup. The automatic navigation system has to be controlled for the full scanning of living room, to recognize the absolute position and orientation of the self, the precise tracking of distinguish the mess object to clean from obstacle object to just avoid. The manipulation system, which is not needed in the vacuum-cleaning robot, must have the functions, how to distinguish big trash to clean from mess objects to arrange, how to grasp in according to the form of mess objects, how to move to the destination in according to mess objects and arrange them. In this paper, a Mess-cleanup Robot, including both the automatic navigation system and the agile manipulation system, is optimally implemented. Then, it should be an intelligent system so that the mess cleaning task can be autonomously performed in a wide variety of situations and environments. But it is yet difficult to develop perfectly intelligent machine. So the HMR needs the help of the human to solve them and clean-up the mess. That is to give too difficult information, to autonomously recognize, to the HMR. The help of the human is condoned through its human interface using speech recognition and synthesis etc. It need to also have the entertainment functions for the good communication between the human and HMR. Therefore, the Home Mess-cleanup

Robot with Entertainmental Human Interface is developed in this paper.

The technological concept of new machine, Home Mess-cleanup Robot, is given in the section II. It is to explain about general system configuration such as actuating, sensing, mechanical design and control for the HMR's navigation. Also, it is to propose the general algorithm such as obstacle avoidance, object segmentation, gripping and arrangement for the HRM's manipulation of mess objects. In the section III, a simplified Home Mess-cleanup Robot, the prototype system which is developed in this paper, is explained in details. The experimental set-up and experimental results is given in the section IV. The living room, in this paper, is made for the experiment and mess environments is situated. Finally, the good performance of the designed machine, HMR'04, is confirmed through the results of the mess clean-up and arrangement.

2. TECHNOLOGICAL CONCEPT OF HMR

Recently, the cleaning robot was developed to perfectly solve the cleaning labor in a house. But the cleaning robot has just an autonomous vacuum-cleaning function. So it also is not successful because it still has the problem of mess-cleanup, which is the cleaning of big trash and the arrangement of newspapers, clothes, etc. The cleaning robot is to just vacuum dust and small trash. It has no function to arrange and take away before the automatic vacuum-cleaning. Therefore, we need a design method and technological algorithm of new automatic machine to solve the problem of mess-cleanup in house. In this paper, a Home Mess-Cleanup Robot(HMR), which has a practical function of the automatic mess-cleanup, is developed. The system configuration of a home mess-cleanup robot is given in the fig. 1.
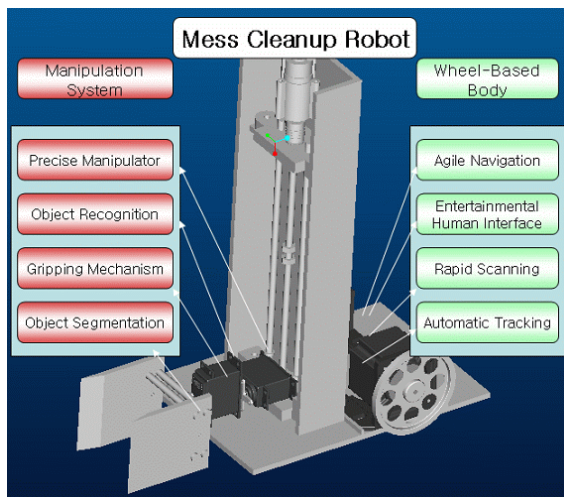

Fig. 1 HMR's System Configuration

A mess-cleanup robot system is divided into two main parts. The mess-cleanup robot is autonomously navigated more precisely than the conventional cleaning robot. The cleaning robot moves according to a wall or scans in a fixed pattern. The navigation method is enough to vacuum dust and small trash, but is not to clean and arrange the mess. Because the mess-cleanup robot have to move to the destination spot with the target object after gripping the one on the contrary to the conventional cleaning robot. Its automatic navigation system has to be controlled for the full scanning of living room, to

recognize the absolute position and orientation of the self, the precise tracking of the desired path, and to distinguish the mess object to clean-up from obstacle object to just avoid.

The mess-cleanup robot has to be able to elaborately manipulate the target object. That is to exactly detect the target object, to correctly grasp the one, to accurately arrange it in the destination spot. To do that, the manipulator has a powerful detection system and a higher degree of freedom. Also, it must have a function lifting the object to arrange in a high destination spot. After all, the mess-cleanup robot is much more agile and intelligent system than the conventional cleaning robot. The manipulation system, which is not needed in the vacuum-cleaning robot, must have the functions, how to distinguish big trash to clean from mess objects to arrange, how to grasp in according to the form of mess objects, how to move to the destination in according to mess objects and arrange them. In this paper, a Mess-cleanup Robot, including both the automatic navigation system and the agile manipulation system, is optimally implemented.

Especially, its detection and navigation system should be intelligent. Or, it should be an intelligent system so that the mess cleaning task can be autonomously performed in a wide variety of situations and environments. It makes a machine quite intelligent to use the vision sensor and to apply the fusion of ultrasonic sensor and RFID tag. But the intelligence of a machine is still limited. It is yet difficult to develop perfectly intelligent machine. So the HMR need the help of the human to solve them and clean-up the mess. That is to give the difficult information in house to the HMR. The help of the human is condoned through its human interface using speech recognition and synthesis etc. It need to also has the entertainment functions for the good communication between the human and HMR. Therefore, the Home Mess-cleanup Robot with interactive and entertainmental human interface is developed in this paper.

The fig. 2 is a scenario for the HMR to process a task. First, it navigates for the scan of a living room. If it is an obstacle, it processes the avoidance algorithm. If it is an object, it processes the mess-cleanup algorithm
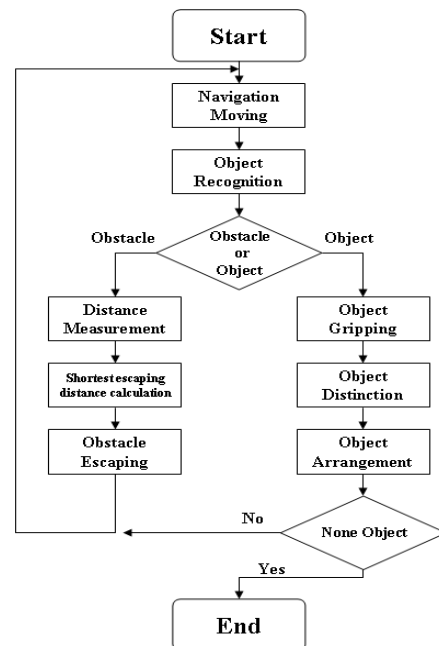

Fig. 2 A Processing Scenario of the HMR's Task

3. A DESIGN OF SIMPLIFIED HMR

This paper designs and embodies a simplified Home Mess-cleanup Robot. The photograph of its inner and outer system designed in this paper is given in the fig. 3.
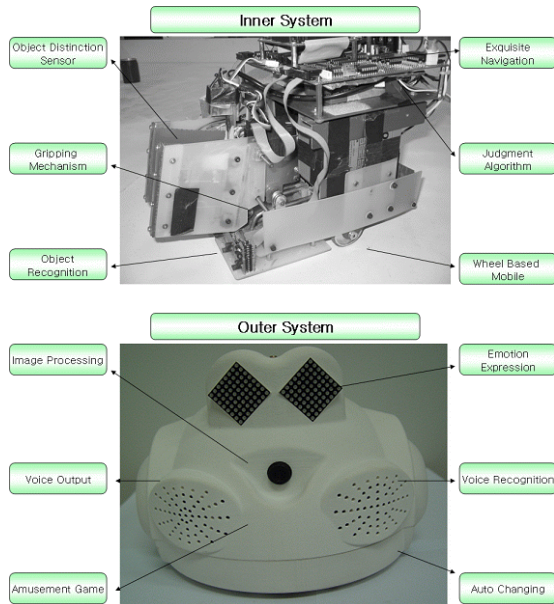

Fig. 3 Photograph of The Designed HMR

HMR of this paper has a mess-cleanup function and an entertainment function. The mess-cleanup function is designed by using wheel-based navigation. HMR have object perception sensor for object perception and wall perception sensor left side and right side of robot for Navigation and distinction sensor on grip part for object distinction. Also, grip of HMR is gone out forward more than body of robot by using rail. So HMR can get hold of body of a narrow space. HMR catch regardless of quality of the material of object being designed to regulate strength of grip by strength of object.

Simplified HMR designed to test with object of pattern that is decided from simplified space. Navigation of HMR is used absolute coordinate in environment work. So HMR is created absolute coordinate by using Electronic Compass and Encoder of motor. HMR grasp structure of the room by next method. First, create room whole size searching priority wall and searches interior next. Scanning algorithm of HMR is shown in the fig. 4.
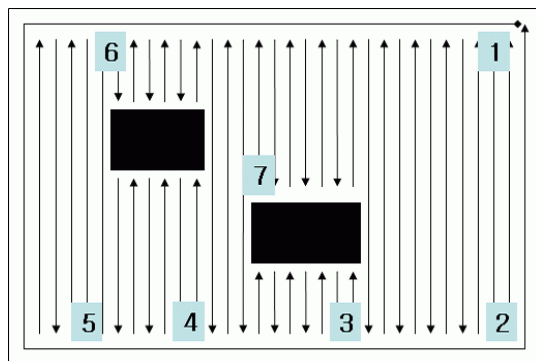

Fig. 4 Scanning Algorithm of HMR

Object that search is judged through cognition system that is explained next. Object that judged is moved to fixed space. Then Object is arrangement putting in order or thrown. Judgment system of object is designed by pattern of object. The classification for mess detection is shown in the fig. 5.
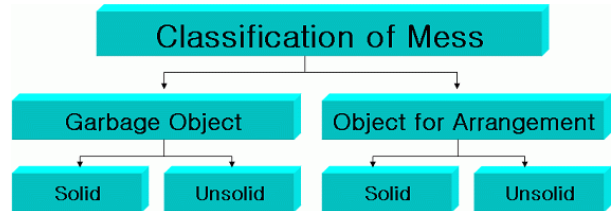

Fig. 5 The Classification for Mess Detection

Object awareness in Simplified System divided pattern with height, form, strength by using multiplex sensor of grip part. Also, Entertainmental Human Interface System is loaded HMR. If HMR do not recognize, ask to user and hear user's answer by using speech recognition. User's answer may help in judgment of HMR

4. EXPERIMENT AND RESULTS

An emulated living Room was made for the experimental set-up of HMR in this paper. The living room was sized by 1800mm X 1800mm. A main obstacle is crossing in center of the living room and its height is 50mm and its length is 900mm. A severe mess-up situation was established. The experimental set-up in a living room is shown in the fig. 6.
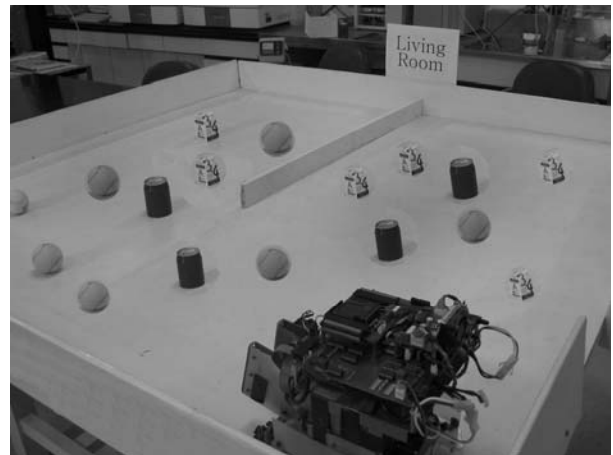

Fig. 6 An Emulated Living Room

In this experimental set-up, the living room is messed up using the various of objects. The cylindrical can and the rectangular milk-pack are used for the big garbage. The spherical ball is put for the target objects to arrange.

This study includes also a development of an entertainmental human interface for the interactive communication between the human and HMR, with emotional model which can feel and express the emotion by using intelligent algorithm. The emotional model is required especially in the entertainment robot. They require several capabilities such as perceiving, acting, communication, and surviving. The user recognizes the communication with a

entertainment robot by observing its expression and reaction. The expression is realized by emotion-based actions based on moving, dancing, sounding, speaking, and lighting. Therefore, we implemented an interactive and entertainmental human interface, using the speech recognition and the colored dot matrix(16X16) , on the Home Mess-cleanup robot.
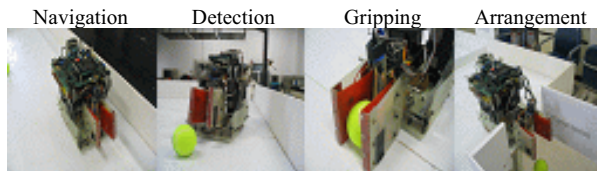
Navigation   Detection   Gripping   Arrangement

Fig. 7 Mess-Cleanup of An Object(Ball)

Navigation   Detection   Gripping   Cleaning

Fig. 8 Mess-Cleanup of An Object(Can)

Navigation   Detection   Gripping   Cleaning
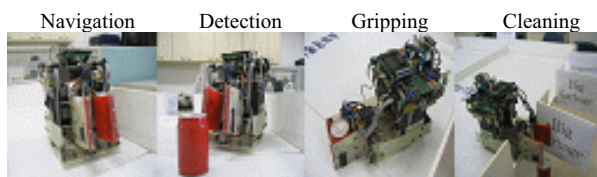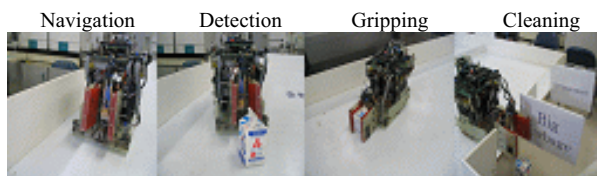

Fig. 9 Mess-Cleanup of An Object(Milk-Pack)

The actual results are given in the fig.7, fig. 8 and fig.9. The fig. 7 shows the process to arrange the balls, the target objects to arrange, messed in the living room. We can know through the figure that both arrangement and navigation are perfectly performed. The fig. 8 and the fig. 9 show the process to clean up can and pack, the big trash, messed in the living room. We can confirm through the figures that detection and clean-up are well condoned

5. CONCLUSION

We proposed a design method and technological algorithm of new automatic machine to solve the problem of mess-cleanup in house. A Home Mess-Cleanup Robot(HMR), which has a practical function of the automatic mess-cleanup, was developed in this paper. It was an agile robot which had functions of stable automatic navigation, noble manipulation system for mess-cleanup.

Then, it should design an intelligent system so that the mess cleaning task can be autonomously performed in a wide variety of situations and environments. But it was yet difficult to develop perfectly intelligent machine. So the HMR need the help of the human to solve them and clean-up the mess. Therefore, the Home Mess-cleanup Robot system, with Entertainmental Human Interface for the help of the human through its human interface using speech recognition and synthesis etc., is developed in this paper. Finally, the good performance of the designed machine, HMR'04, is confirmed through the results of the mess clean-up and arrangement.

5. UNITS AND SYMBOLS

5.1 Units

5.2 Symbols

HMR : Home Mess-Cleanup Robot.

REFERENCES

[1]   Proceedings of the 2001 IEEE/RSJ〝International Conference on Intelligent Robots and Systems〞, Maui, Hawaii, USA, Oct. 29 - Nov. 03, 2001.

[2]   Funge, J., Tu, X. and Terzopoulos, D. 1999. Cognitive Modeling: Knowledge, Reasoning and Planning for Intelligent Characters. In Proceedings of SIGGRAPH 99, 29-38.: New York, NY. ACM SIGGRAPH.

[3]   Yoon, S.-Y. 2000. Affective Synthetic Characters. Ph D. diss. Department of Brain and Cognitive Sciences, Massachusetts Institute of Technology. Forthcoming.

[4]   Breazeal (Ferrell), C. A motivational system for regulating human-robot interaction. In Proceedings of AAAI 98. Madison, WI, 1998.

[5]   Kline, C. and Blumberg, B. The Art and Science of Synthetic Character Design. Proceedings of the AISB 1999 Symposium on AI and Creativity in Entertainment and Visual Art, Edinburgh, Scotland, 1999.

[6]   Paulos, E. and Canny, J. 1998. Designing personal tele-embodyment. In Proc. IEEE Int. Conf. Robot. Automat., pp. 3173-3178.

[7]   S.Maeyama,S.Yuta and A.Harada, Experiments on a Remote Appreciation Robot in an Art Museum, Proceedings of IROS 2000, pp. 1008-1013, 2000

[8]   K. Kawamura, R. T. Pack, M. Bishay, and M. Iskarous, "Design philosophy for service robots", Journal of Robotics and Autonomous Systems, vol. 18, pp. 109-116, 1996.

[9]   Wijk and H. I. Christensen, "Localization and navigation of a mobile robot using natural landmarks extracted from sonar data", Robotics and Autonomous Systems, vol. 31, pp. 31-42, 2000.

[10] Y.Matsumoto, K. Ikeda, M. Inaba, and H. Inoue, "Exploration and map acquisition for view-based navigation in corridor environment", in Proceedings of the International Conference on Field and Service Robotics, Pittsburgh, Pennsylvania, August 29-31 1999, pp. 341-346.

[11] V. D. Hardt, P. Arnould, D. Wolf, and M. Dufaut, "Method of mobile robot localisation by fusion of odometric and magnetometric data", International Journal of Advanced Manufacturing Technology, vol. 9, no. 1, pp. 65-69, 1994.

[12] R. Baker, Human Navigation and the Sixth Sense, Simon and Schuster, New York, 1981.

[13] B. J. Kuipers and Y. T. Byun, "A robot exploration and mapping strategy based on a semantic hierarchy of spatial representations", Journal of Robotics and Autonomous Systems, pp. 47-63, 1991.