Development of a Bio-mimetic Entertainment Robot with Autonomous Feeding Functionality

Ik-Jin Cho*, Byoung-Jun Choi*, Kil-Woong Jeong*, and Yun-Jung Lee**
*Graduate School of Electronic Engineering, Kyungpook National University, Daegu, Korea
(Tel : +82-53-940-8662; E-mail: jiny0588@palgong.kun.ac.kr)
**School of Electrical Engineering and Computer Science, Kyungpook National University, Daegu, Korea
(Tel : +82-53-950-6562; E-mail: yjlee@ee.knu.ac.kr)

Abstract: Most of the recently developed robots are human friendly robots which imitate an animal or human such as entertainment robot, bio-mimetic robot and humanoid robot. Interest in these robots are increasing since the social trend is focused on health, welfare, and graying. By these social backgrounds, robots become more human friendly and suitable for home or personal environment. The more bio-mimetic robots resemble living creature, the more human feels familiarity. People feel close friendship not only when they feed a pet, but also when they watch a pet having the food. Most of entertainment robots and pet robots use internal-type batteries and have a self-recharging function. Entertainment robots and pet robots with internal-type batteries are not able to operate during charging the battery. So far there have been a few robots that do not depend on a battery. However, they need a bulky energy conversion unit and a slug or foods as an energy source, which is not suitable for home or personal application. In this paper, we introduce a new bio-mimetic entertainment robot with autonomous feeding functionality, called ELIRO-1(Eating LIzard RObot version 1). The ELIRO-1 is able to find a food (a small battery), feed by itself and evacuate. We describe the design concept of the autonomous feeding mechanism of the ELIRO-1, characteristics of sub-parts of the manufactured mechanism and the control system.

Keywords: Bio-mimetic Robot, Autonomous Feeding, ELIRO-1, Entertainment Robot

1. INTRODUCTION

Most of the recently developed robots are human friendly robots which imitate an animal or human such as entertainment robot, bio-mimetic robot and humanoid robot. Interest in these kinds of robots are increasing since the social trend is focused on health, welfare, and graying. By these social backgrounds, robots become more human friendly and suitable for home or personal environment. The more bio-mimetic robots resemble living creature, the more human feels familiarity. People feel close friendship not only when they feed a pet, but also when they watch a pet having the food.

(a) AIBO

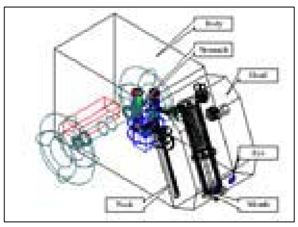
(b) PALO

Fig. 1 Entertainment robot and Pet robot

Most of entertainment robots and pet robots use an internal-type battery. Entertainment robots and pet robots with internal-type battery are not able to operate during charging the battery. So far there have been a few robots that don't depend on a battery. They are the Slugbot (Lan Kelly, 2000) [1]~[3] and the Gastrobot (Wilkinson, 2000) [4]. The Slugbot in California Institute of Technology is capable of autonomous action on agricultural land by eating slugs. The Gastrobot in University of South Florida obtains energy from sugar. A common point of these robots has an energy converter to use real food as a source of energy and a fuel cell to store the converted electricity. They need a bulky energy conversion unit and a slug or foods as an energy source. Therefore, they are not suitable for home or personal application.

(a) Slugbot

(b) Gastrobot



(c) EPRO

Fig. 2 Conventional eating robot

To improve the applicability of robots in home and personal environment, we have come up with the use of small batteries as an energy source of an eating robot. Recently, our research group has introduced about the basic mechanical design of a bio-mimetic entertainment robot (Park Chae-Su, EPRO, 2003) [9]. In this paper, we introduce a new bio-mimetic entertainment robot with autonomous feeding functionality, called ELIRO-1(Eating LIzard RObot version 1). The ELIRO-1 is able to find a food (a small battery), feed by itself and evacuate. We describe the design concept of the autonomous feeding mechanism of the ELIRO-1, characteristics of sub-parts of the manufactured mechanism and the control system.

2. DESIGN CONCEPT OF AUTONOMOUS FEEDING MECHANISM

The ELIRO-1 is not only an eating robot but also a quadruped walking robot with articulated spine (waist joint). The ELIRO-1 is modeled after a lizard and it is able to take small battery (food) by using tongue like a lizard does. In addition, the autonomous feeding mechanism of the ELIRO-1 consists of eye-part, mouth-part, neck-part and stomach-part. Each mechanical part has designed by a commercial CAD tool, CATIA. Using the 3D design tool of the CATIA, we can verify the operation of mechanisms before manufacturing. The overall design drawing of the ELIRO-1 is shown in Fig. 3.

In the design, we have considered basic requirements for each mechanical part and controller part as summarized in Table 1. The design requirements are taken into account in the whole process of development of the robot.

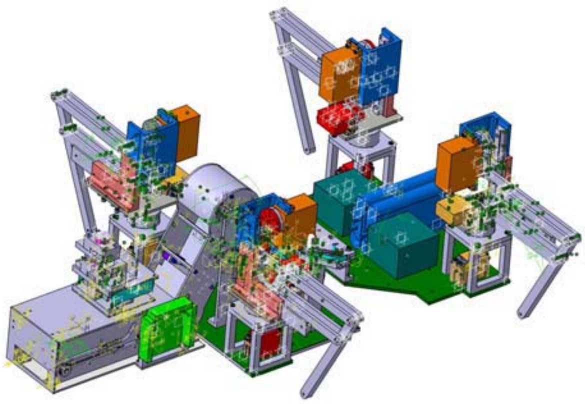


Fig. 3 Overall design drawing of the ELIRO-1

Table 1 Design requirement of the feeding mechanism

Class	Item	Design requirement
Mechanical Parts	Eye-part	Small size, light weight, enough resolution to detect a food battery
	Mouth-part	Light weight, reliable catching of food batteries
	Neck-part	Move the head part, easy to swallow a battery
	Stomach-part	Efficient for storing and defecating food batteries
Controller Part	Sensor	Small size, discriminate food batteries from the ground
	Microprocessor	Enough performance to drive motors, to process sensor information and to
Food	Secondary battery	Small size, low cost

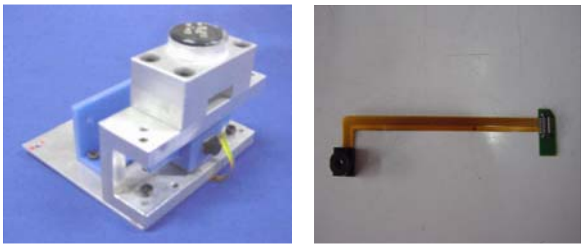
3. STRUCTURE OF THE DEVELOPED MECHANISM

As mentioned above, a secondary battery is decided as the food of the ELIRO-1. The size, the shape and the characteristic of the battery are important parameters in the realization of all mechanical parts. The chosen food battery is a small button-type Ni-Cd battery which is 1.2V in voltage output, 80mAh in capacity, 15.4 mm in diameter and 5.5 mm in height. The constructed prototype of the ELIRO-1 is shown in Fig. 4.

Fig. 4 ELIRO-1

3.1 Eye-part

The eye-part is essential to find a small-sized button-typed food-battery. To be it as small and light as possible, we use a small-sized CMOS image sensor and two SMA (Shape Memory Alloy) actuators which move the image sensor. A potentiometer sensor is used to detect the rotational angle of the image sensor.

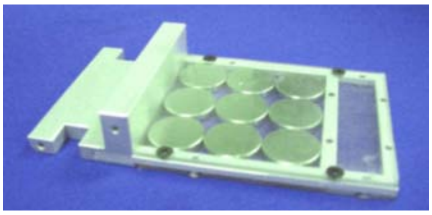


(a) Eye-part (b) CMOS image sensor

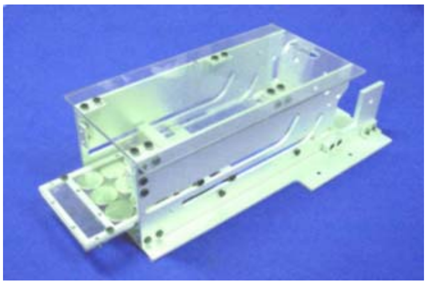
Fig. 5 Eye-part of ELIRO-1 and CMOS image sensor

3.2 Mouth-part

The mouth-part is a part for picking up battery. There are some alternatives to implement the mouse-part such as gripping method, biting method, and sticking method. The gripping method using hand or feet and the biting method using mouth usually need a complicated mechanism, a precise position control to pick up a small-sized battery, and a force control in consideration of contacting with the ground. To resolve those complex problems, we propose the sticking method in which a magnet-tongue is used to stick up the battery from the careful observation that the case of the food battery is made of steel. The sticking method is relatively easy to implement and free from the complex control problems.



(a) tongue



(b) mouth-part

Fig. 6 Mouth-part and tongue

There are two main issues for the design of the mouth-part using the sticking method. The first is separation of food-battery from magnet of tongue. The second is blocking of the magnetic force from passage of the battery. To resolve those issues, we design a mechanism that operates as follows. Food-battery stuck to magnet is pushed and dropped down to the passage at the end the tongue as tongue moves inside. The blocking of the magnetic force accomplished by L-shaped transfer path of the tongue (as shown in Fig. 8). Since the distance between two L-shaped transfer path is always same as shown in Fig. 8, the tongue is kept to be parallel with the ground.

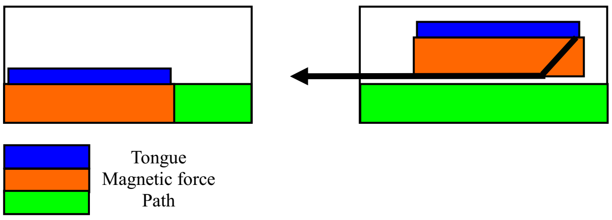


Fig. 7 Movement of tongue and magnetic force area

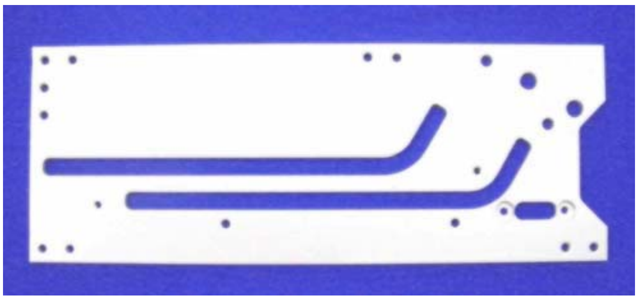


Fig. 8 Transfer path of the tongue

3.3 Neck-part

Through the neck-part, a food-battery slides down to the stomach-part. Like the motion of animals, the robot's head (including the eye-part and the mouth-part) is lifted up to make a food-battery slide easily.

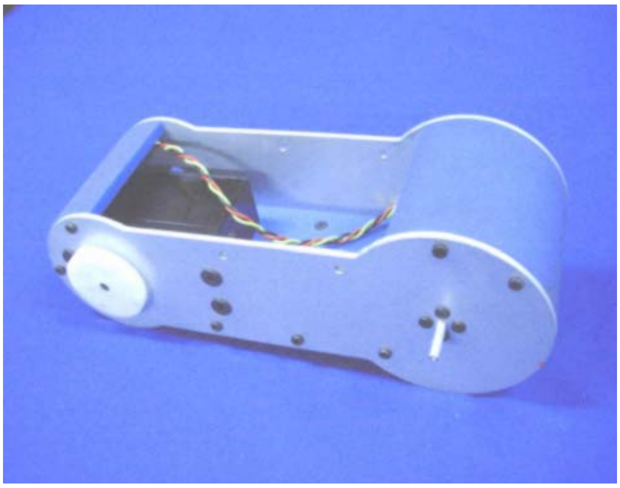


Fig. 9 Neck-part

3.4 Stomach-part

In the stomach-part, the polarity of the battery is checked and it is stored. A 2-dof mechanism turns a battery with reverse polarity upside down and pushes a battery into a battery pack. Five food-batteries are serially connected in a battery pack. Two packs of fully charged batteries are linked in parallel. The exhausted batteries are expelled out. Currently, the feeding batteries are used only for driving of small part of the robot since the available battery has very small capacity.

3.4.1 Polarity check

The polarity check part is a part that checks polarity of a food-battery to store batteries with same polarity in a battery pack. Polarity check is performed in the middle of transfer path of a food-battery. A bar pushes the battery into the polarity check part. The polarity of a battery is checked by contacting with two electric terminals. The polarity check part rotates to turn the battery upside down if its polarity is reversed.

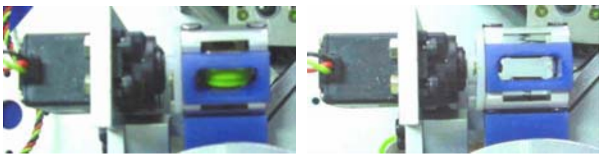


Fig. 10 Polarity check part

3.4.2 Battery pack

Four battery packs are mounted on a battery disk. A battery pack can store five food-batteries. Among four packs, two packs have fully charged batteries, one pack has exhausted batteries to be defecated and one pack is stored by new batteries. In the current design, only the energy to move the tongue is used by fully charged batteries of one pack. Five fully charged batteries of one pack can supply the power with voltage of 6V and current of 80mAh. Negative poles of all battery packs are tied with a lower-disk. The positive pole of a battery pack in use is contacted with a terminal of battery upper-disk. The gear of the lower-disk is made of the monocast nylon to insulate electricity.

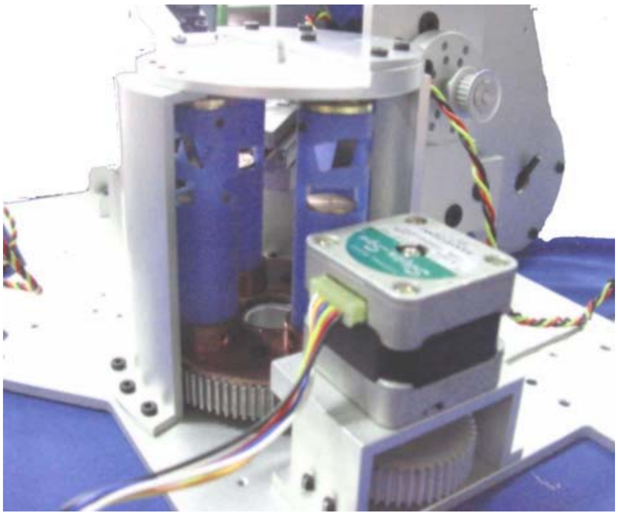


Fig. 11 battery disk (stomach)

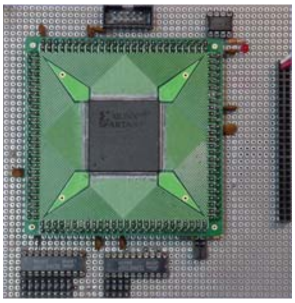
4. CONTROL SYSTEM

4.1 Controller hardware

Main microcontroller board is based on a 32-Bit Digital Signal Controller, TMS320F2812PGFA of TI (shown in Fig. 12 (a)). First function of the microcontroller board is processing image information which is received from a CMOS image sensor. Image data that come out from a CMOS image sensor is saved into a SDRAM through an image sensor interface. Second function is motor control of the robot. Number of motors used for autonomous feeding mechanism is seven.

(a) Microcontroller board

(b) CMOS image sensor interface board



(c) RC servo motor driver

(d) DC motor, SMA and Stepping motor driver

Fig. 12 Developed controller hardware boards

Five RC servo motors, one small DC motor and one step motor are used for driving the neck/stomach-part, the tongue-part and the rotational disk of battery pack, respectively. The motor interface boards (Fig. 12 (c) and (d)) are implemented by using a FPGA and a power transistor chip, L298.

4.2 Control Sequence for autonomous feeding

The control sequence of the ELIOR-1 for autonomous feeding can be divided into 8 steps according to the location of a battery as shown in Fig. 13. At the beginning, the ELIRO-1 should have at least 10 fully charged batteries.

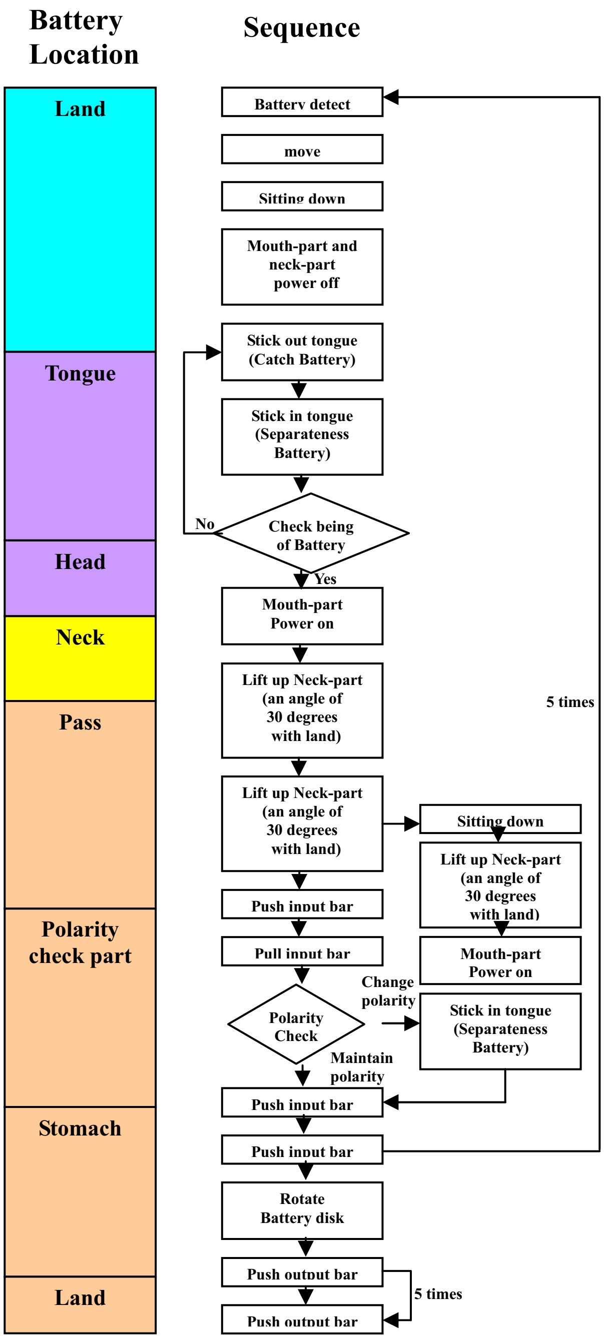


Fig. 13 Flowchart of the autonomous feeding sequence

After finding a food-battery, the ELIRO-1 eats the battery and stores it in a battery pack. This action should be repeated 5 times. If currently used batteries are exhausted, the disk of battery packs rotates and exhausted batteries are expelled out.

5. CONCLUSION

In this paper, we proposed a new human friendly bio-mimetic entertainment robot with autonomous feeding functionality, the ELIRO-1. We introduced about the mechanism and control system of the prototype ELIRO-1. The ELIRO-1 is able to eat a food-battery and to use a food-battery as a source of energy. The ELIRO-1 is similar with a real animal in the viewpoint of external shape as well as internal structure.

We hope that the autonomous feeding concept will open a new paradigm of bio-mimetic robots and entertainment robots. We are going to develop a more human friendly bio-mimetic entertainment robot through miniaturization of robot mechanism and use of high efficient food-battery.

ACKNOWLEDGEMENTS

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