Demura.net 2015 Team Description

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Abstract. This paper describes our research interests and technical information of the demura.net team for the RoboCup@Home league of the RoboCup 2015 world competition. The Demura Research Laboratory from the Kanazawa Institute of Technology has developed autonomous service robots named "Kenseiko-Chan" and "Kenseiko-Chan Mobile". This paper will discuss the mechanical and software systems of the robots in detail as well as present algorithms of motor control and perception. Finally, this paper will explore the applications of the robot and outline the team's future development goals.

Keywords: RoboCup@Home, Child care robot, Picture book reading

1 Introduction

The Demura Research Laboratory team has been participating in the RoboCup@Home league of the RoboCup Japan Open since 2012, and this is our first attempt to participate in the RoboCup@Home league of the World Championship. The current team advisor, Professor Kosei Demura, participated as an advisor for the WinKIT team in the World Championship in the Middle-Size League (MSL) in 1999, 2000, 2002-2006, 2009, and the Humanoid League in 2010. From 2002 to 2004, the WinKIT team held the title of vice world champion [1].

The MSL is very attractive, fun, and enthusiastic for participants and large audiences. However, the robots of MSL are not useful and helpful to people directly. This caused our team to reflect upon its goals. Thus, our team decided to develop two kinds of human support robots. One is a childcare robot and another is a wheelchair robot for the elderly. To foster the research and development, the Demura Research Laboratory has been participating in RoboCup@Home since 2012 and Tsukuba Challenge since 2008 [2].

The robot for Robocup@Home, Kenseiko-chan, is named after the Professor Demura's child and "chan" is the diminutive suffix to show friendliness to a young girl in Japan. The robot is designed in the image of a young girl with a lively yellow color. The software system was based on the Robotics Technology Middleware (RT-middleware) developed by Agency of Industrial Science and Technology (AIST) [3].

Starting last year, the system has been reforming based on Robot Operating System (ROS).

The rest of the paper is as follows. Section 2 describes the hardware of the robots; Section 3 describes the software system and the algorithm of motor control and perception. Finally, this paper will conclude by exploring applications and denoting future work.

2 Hardware Architecture

2.1 Design Concept

Exterior Design. Our robot is used for childcare, so the exterior design is crucial. The team believes that a lovely and friendly exterior design is suitable for childcare. Professor Demura designed the face and printed it out using a 3D printer.

Safety. Safety is the most important thing for the childcare robot. The robot should be lightweight, use minimal power, and fingers cannot be inserted in the joint parts. Therefore, joint parts are covered, and a damping system is adopted in the shoulder joint.

Usability. Maintenance and transportability are important to participate in the RoboCup. The robot is easily folded for transportation.

2.2 Specifications

Fig.1 and Fig.2 show our robots, Kenseiko-chan and Kenseiko-chan mobile, respectively. Kenseiko-chan is 1.35 [m] tall, 19.0 [kg] heavy with two arms and was fully developed by our laboratory. Kenseiko-chan mobile has one arm with an xtion sensor and has been developing based on the Kobuki base. Specifications of those robots are shown in Table 1.

Fig.1. Childcare robots Kenseiko-chan (*left*) and Kenseiko-chan Mobile (*right*)

Table 1. Robot Specifications

	Kenseiko-chan	Kenseiko-chan Mobile
Height [m]	1.35	0.7
Width [m]	0.50	0.3
Length [m]	0.50	0.3
Weight [kg]	19.0	8.0
Max speed [m/s]	0.7	0.7
D.O.F	12	3

2.3 Mechanical System

Platform. Fig.2 shows the platform of Kenseiko-chan. The platform is an omni-directional moving system which has 4 Mecanum wheels. The max speed of it is 0.7 [m/s]. A notebook computer is mounted on the top of the platform, and another computer can be mounted in the platform. Arduino Mega 2560 is used to control the platform, it controls the motor (RE30, Maxon) and reads pulses from encoders, and 1 XP power modules by Hibot are used for the motor drivers.

To improve the maintenance, the motor, the reduction gear (GP32A, Maxon), and the Mecanum wheel (TDAM-0137, AndyMark) are easily attached and detached and the robot is easily folded for transportation as shown in Fig.2.

Neck. Neck has 2 DOF (pitch and yaw). Parts of each joint of the neck is the same as the arms and the hands.

Arm. The DOF of the arm is 5 (shoulder 2, elbow 1, wrist 2), and two arms are attached to the shoulder. 5 servo motors (RS405CB, Futaba) are used in each joint. To avoid vibration and gravity compensation, a rotary damper (FRN-F2-R203, Misumi) is embedded in the shoulder as shown in Fig.4. The rotary damper is also useful for safety. Even in the case of the electricity shutdown, the arms are slowly down by the

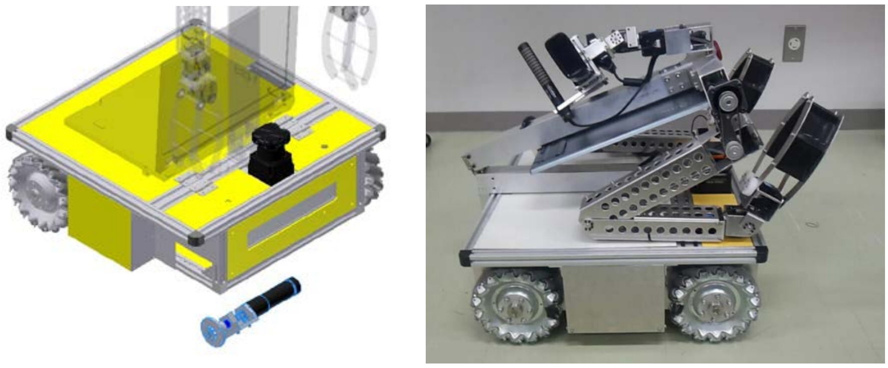

Fig.2. The platform *(left)* and its folded state for transportation *(right)*

Fig.4. The shoulder and neck mechanism

Fig.5. Kenseiko-chan with old arms

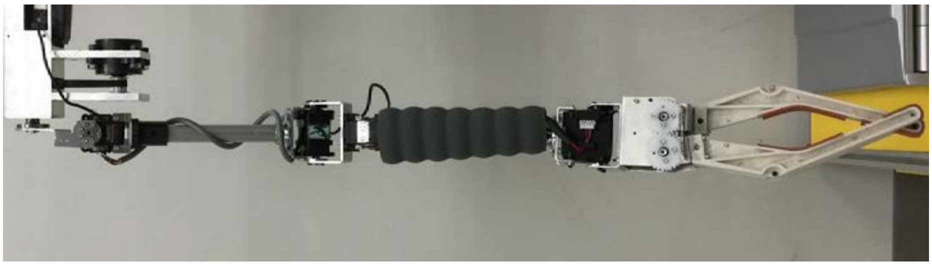

Fig.6. Kenseiko-chan's new arm

rotary damper. The weight of the arm as shown in Fig.5 is 880 [g]. The motor of the shoulder is not powerful enough, so a new lightweight arm has been developed. The weight of the prototype arm is 780 [g]. The arm can lift up an object up to 550 [g].

Hand. The hand is also redesigned using a 3D printer (Replicator 2X, MakerBot) and implementing a spring, which helps grasping an object as shown in Fig.7. Because of this, it is now able to grasp thinner objects as well as hold objects for a long time. It can hold up to 550 [g] without using the power of a motor.

Fig.7. The old hand (*left*) and the new hand (*right*)

2.3 Electrical Systems

Fig.8 shows the diagram of the electrical system of Kenseiko-chan. The robot is controlled by a notebook computer (ThinkPad T410, Lenovo) with an Intel Core i7 processor and 4GB memory. The robot uses 4 LiFePO4 batteries (6.6 [V], 2200 [mAh], Cosmo energy), two for the platform and the other for arms and sensors.

Internal Measurement Unit (IMU). MicroStrain, 3DM-GX3-25 triaxial accelerometer, triaxial gyro, triaxial magnetometer, temperature sensors

RGB-D Sensor. XTION Pro Live, ASUS

Lidar. UTM 30 LX, Hokuyo

Encoder. Maxon MR (Magneto-resistant)

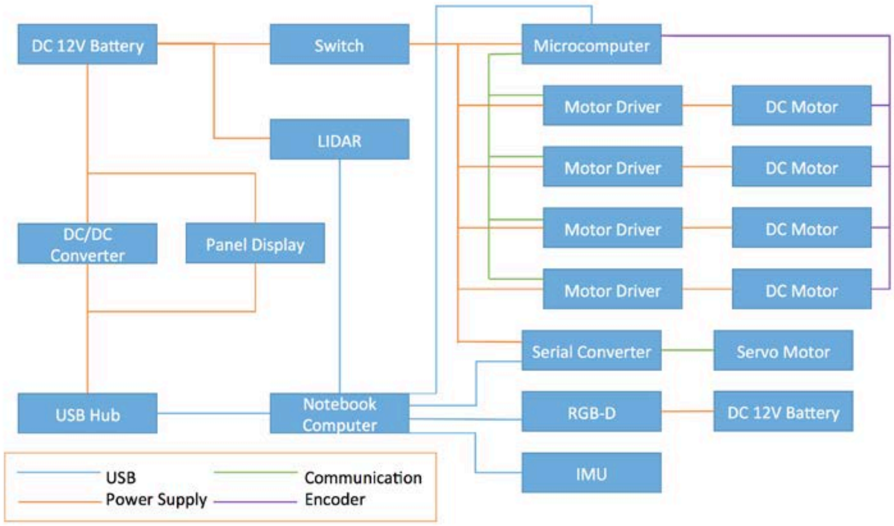

Fig.8. The electrical system diagram for Kenseiko-chan

3 Software Architecture

3.1 Overview

The software system was based on the RT-Middleware (Robotics Technology Middleware) developed by AIST (Agency of Industrial Science and Technology, Japan). The system has been reformatted using ROS, and is composed of 6 components as follows and shown in Fig.9.

(1) Sensor Input. Input data from RGB-D, Lidar, IMU sensors, and output to the perception and the motor control component.

(2) Speech recognition. Input data from a microphone, and recognize the voice and output data to the state transition component.

(3) Perception. Memorizing and recognizing objects and human faces. Input data from the sensor component and output data to the motor control components.

(4) State Transition. Input data from the perception and speech recognition components and output to the voice output and motor control components.

(5) Voice Output. Output the voice data to a speaker.

(6) Motor Control. Input data from the sensor components and control all motors in the robot.

3.2 Perception

Several algorithms are used for object and human face recognition.

Object recognition. SURF feature detector, extractor, and matcher are used [4]. Furthermore, Iterative Closest Point (ICP) algorithm is used for point clouds data.

Human recognition. The Histogram of Oriented Gradients (HOG) feature descriptor is used for learning Real Adaboost [5]. 2000 positive examples and 10000 negative examples are used for recognizing humans as shown in Fig.10. The recognition rate is more than 90%, even in outdoor environments.

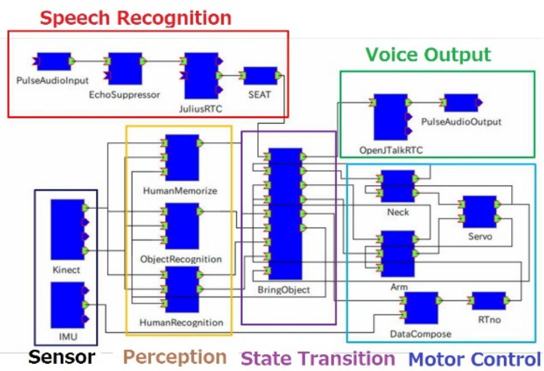

Fig.9. The Software system based on RT-Middleware

Fig.10. The results of human detection (red is correct, blue is incorrect)

3.3 Navigation

The team developed an algorithm that can solve the significant problem of the waypoint-based navigation that is the positions of the waypoints can be located in unreachable areas due to errors in self-localization and the map [6].

Gmapping, Adaptive Monte Carlo Localization (AMCL) [7], and Dynamics Windows Approach (DWA) [8] algorithms are used for SLAM, localization, and collision avoidance, respectively.

3.4 Speech Recognition

Julius is used for Japanese speech recognition, which is an open-source large-vocabulary speech recognition engine [9], and pocketsphinx is used for English speech recognition.

3.5 Speech Synthesis

Speech synthesis is crucial for childcare, so the AI talk used is a commercial human-like natural speech synthesis software. Kenseiko-chan mobile uses voice of a little boy model.

4 Conclusion

The robots “Kenseiko-chan” and “Kenseiko-chan Mobile” are designed with the goal of not only taking care of children, but also to educate them. Our team aims to improve our robots so they can be used to assist children in many settings, such as at home and at school. For example, the team demonstrated picture book reading at the RoboCup Japan Open 2013 and 2014 as shown in Fig.11.

We are using the Robocup@Home challenges as a basis for the robot and will work toward completing more tasks. However, outside of Robocup@Home, we hope to brainstorm new ideas and implement new technologies to make our robots more applicable to real-life situations.

Fig.11. Demonstration of picture book reading

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