The demura.net 2016 Team Description

Kosei Demura[1], Kensei Demura[2], Kazuki Nagashima[1], Koyo Enomoto[1]

[1]Kanazawa Institute of Technology, Department of Robotics
7-1 Ohgigaoka Nonoichi, Ishikawa / 921 – 8501, Japan
demura@neptune.kanazawa-it.ac.jp
http://demura.net/robocupathome

[2] Meisei High School
10-23 Honchiba Chuo-ku, Chiba /260-0014, Japan

Abstract. This paper describes our research interests and technical information of the demura.net team for the RoboCup@Home league of the RoboCup 2016 World Competition. The Demura.net team from the Kanazawa Institute of Technology has developed an autonomous service robot named “Happy Mini” for little child and elderly. This paper describes the mechanical and software systems of the robot in detail as well as present various algorithms, and research contribution. Finally, this paper explores the applications of the robot and outline our future research goals.

Keywords: RoboCup@Home, Kawaii design, Deep neural networks

1 Introduction

The Demura.net team has been participating in the RoboCup@Home league of the RoboCup Japan Open since 2012, and participated in the RoboCup 2015 world competition. Notwithstanding it was our first attempt to participate in the World Championship, the team cleared the stage 1 and got the 9th place in the stage 2.

The vision of the demura.net team is “Making the World Happy by Making a Kawaii Robot,” and the identity of our robot as shown in Fig.1, Happy Mini is kawaii and Kawaii is an adjective in Japanese. The meaning is cute, lovely, charming. We think that the kawaii robot can solve problems of an aging society in Japan, robots in the RoboCup@Home league should be more kawaii, Mini is designed in the image of a little child with a lively yellow color. Mini is considered to be the first kawaii designed robot in the RoboCup@Home.

The software system was based on the RT-middleware (Robotics Technology) developed by AIST (Agency of Industrial Science and Technology, Japan) [1], from last year, the system is completely changed by ROS (Robot Operating System). A few years ago, RT-middleware was popular in Japan, however, ROS is now more popular than RT-middleware in Japan.

The rest of the paper is as follows. Section 2 describes the hardware of the robots, Section 3 describes the software system and various algorithms, Section 4 presents the research contribution of our team. Finally, this paper concludes by exploring applications and denoting future work.

2 Hardware Architecture

2.1 Design Concept

Kawaii Design. Kawaii is the design concept for Happy Mini. It is used for childcare and conversation partner for elderly, and also for persons feel lonely living alone, thus the exterior design is crucial. The team believes that a lovely and friendly exterior design is considered to be suitable for those persons.

Simplicity. Simplicity is the key concept of Happy Mini. It reduces size, costs, troubles, and also danger. To realize the simplicity, the commercial base, the Kobuki base, is adopted as the platform. It is easily programmed and operated by ROS.

(a) CAD drawing of Happy Mini (b) Happy Mini (c) Kenseiko-chan

Fig.1. Happy Mini

Table 1. Robot Specifications

	Happy Mini	Kenseiko-chan
Height [mm]	1100~1500	1350
Width [mm]	320	500
Length [mm]	320	600
Weight [kg]	10.0	19.0
Max speed [m/s]	0.7	0.7
D.O.F	7	12

Safety. Safety is the most important thing for the childcare robot. The robot should be lightweight less than 10[kg], minimal power, and fingers cannot be inserted in the joint parts. Therefore, joint parts are covered.

Usability. Maintenance and transportability are very important to the human support robot, and also an @Home robot. The robot is easily folded for transportation, and it can be brought as a carry-on baggage on an airplane.

2.2 Specifications

Fig.1 shows our robots, Happy Mini and Kenseiko-chan, respectively. Kenseiko-chan is the first generation, and Mini is the second generation. Mini was developed to participate in the RoboCup World Championship. Mini is from 1100 to 1500 [mm] tall, 10.0 [kg] heavy with 4 DOF arms with a gripper and was fully developed by our laboratory. The platform of Mini is Kobuki base and equipped the RGB-D sensor (ASUS, Xtion Pro Live) and the Lidar (Hokuyo, UTM-30LX). Specifications of those robots are shown in Table 1.

2.3 Mechanical System

Platform. Fig.2 shows the platform of Mini. The platform is the Kobuki base that is a low-cost mobile research base designed for education and research.

Torso and Neck. The torso is the extensible as shown in Fig.2, and the commercial electric extendable cane, the SHINSUKESAN (ITK Co. Ltd), is used. It is only 0.36 [kg], rated for up to 100 [kg], extends and retracts to 400 [mm]. Neck has 1 DOF (pitch).

Arm and Hand. The DOF of the arm is 4 (shoulder 1, elbow 1, wrist 2) and composed of Link1 (470[mm]), Link2 (160[mm]), and Link3 (270[mm]), 5 servo motors (RS405CB, Futaba) are used, 2 in shoulder and wrist, 1 in elbow. The weight of the arm and hand as shown in Fig.3 is 864 [g]. The servo motor is not so powerful

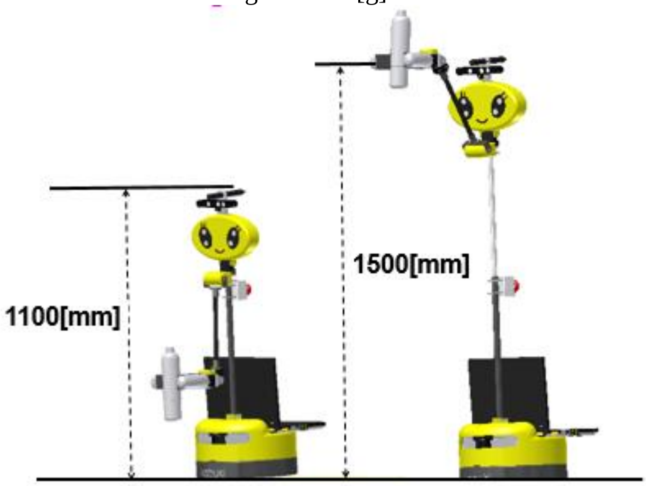


Fig.2. The extendable torso

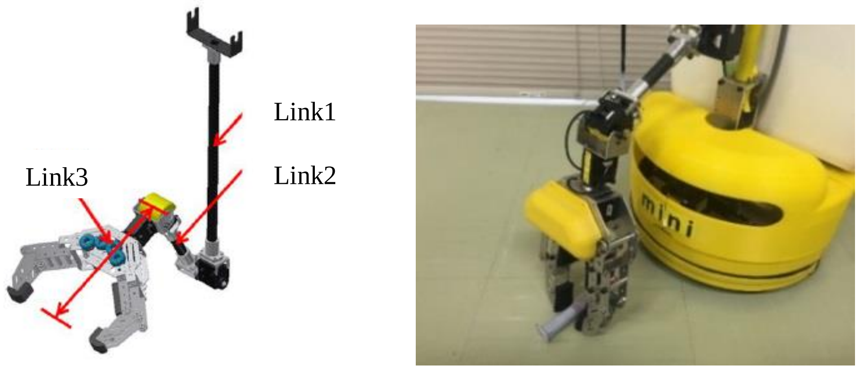


Fig.3. The arm *(left)* and hand *(right)*

(4.7[Nm]), 2 motors are used for the shoulder. The arm can lift up an object up to 550 [g]. The hand is also redesigned to have a capability of grasping an object, from a thin pen to a box up to 150 [mm] on the ground as shown in Fig.3. It adopts a parallel link mechanism to realize the capability.

2.3 Electrical System

Fig.4 shows the diagram of the electrical system of Happy Mini. The robot is controlled by a notebook computer (ThinkPad T450, Lenovo) with a CPU (Intel Core i7), a GPU (NVidia 940M), and 16GB memory. All electricity is supplied by the Kobuki base. It can provide 5V/1A, 12V/1.5A DC, and 12V/5A DC. The system is very simple benefit from the Kobuki base.

3 Software Architecture

3.1 Perception

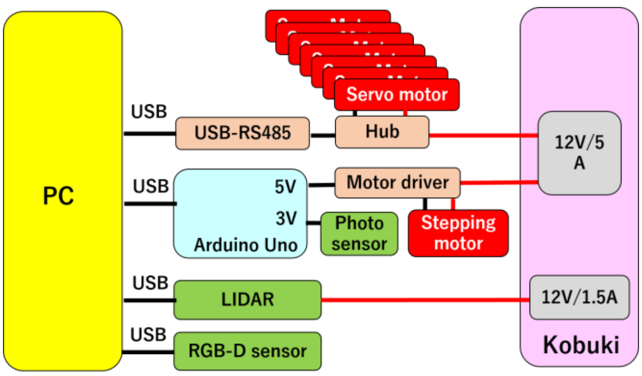


Fig.4. The electrical system diagram of Happy Mini

The software system is based on ROS and Caffe. Several algorithms are used for an object and human face recognition.

HaarCascade classifier [2], Flat Clustering filtering, and Deep Neural Networks (DNNs) are used for face recognition (Fig.5). Nesterov's accelerated gradient [3] and Convolution DNNs are used for gender classification.

3.2 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 [4].

Gmapping, Adaptive Monte Carlo Localization (AMCL) [5], and Dynamics Windows Approach (DWA) [6] algorithms are used for SLAM, localization, and collision avoidance, respectively.

3.3 Speech Recognition and Speech Synthesis

The authors developed a hybrid speech recognition system. The Pocketsphinx is used for the recognition of the keyword, i.e., the robot name. After the keyword recognition, the voice information is processed by the Kaldi that is a toolkit for speech recognition, and DNN implementation for automatic speech recognition.

Speech synthesis is crucial for childcare, so the AI talk, a commercial human-like natural speech synthesis software, is used in Japanese. Mini uses voice of a little boy model. In English, the authors tried some open source TTS (text-to-speech) software, i.e., eSpeak, Festival, and MarryTTS. However, they are not comparable with the AI talk. To find the high quality TTS software in English, is one of our future works.

3.4 Natural Language Processing

The team developed a software to understand English language sentences. The team uses this software to enable the robot understand the meaning what the people talk.

It can understand part of speech per each token in the sentence by using NLTK (Natural Language Processing Kit) tagger software framework, and it can understand the meaning of sentence by matching from the 5 basic sentence pattern of English (SV, SVO, SVC, SVOO, SVOC). It can understand the pronoun by memorizing the

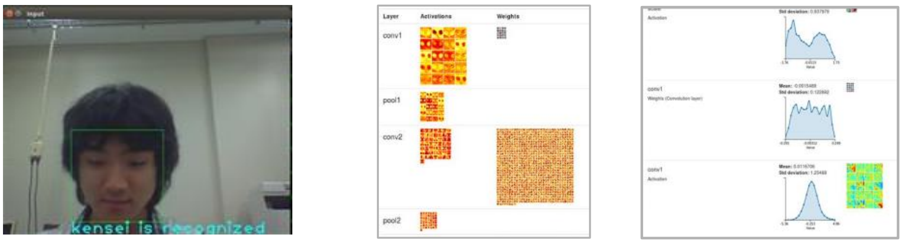


Fig.5. Face recognition using HaarCascade and DNN

order of the noun in a list data structure, and also understands synonyms by searching from the WordNet in the NLTK. It is very robust matching a registered sentence from a voice input by using N-gram based Chatbot algorithm.

3.5 Simulator

Robot simulator is an essential tool for rapid development. We have developed the Happy Mini simulator using the Gazebo robot simulator as shown in Fig.6. To make the 3D Happy Mini model in the simulator, we described the URDF (Universal Robotics Description Format) file and imported 3D meshes from the 3D CAD data. MoveIt! is easily applied to the 3D model described by the URDF (Fig.6).

4 Research Contribution

The first author’s laboratory has been developing autonomous wheelchairs. The conventional wheelchair is difficult to get over small difference (about 30 [mm]) in level, and it sometimes makes a falling accident. To prevent the accident, the capability of detecting the small difference is required. The author is proposing two solutions as follows.

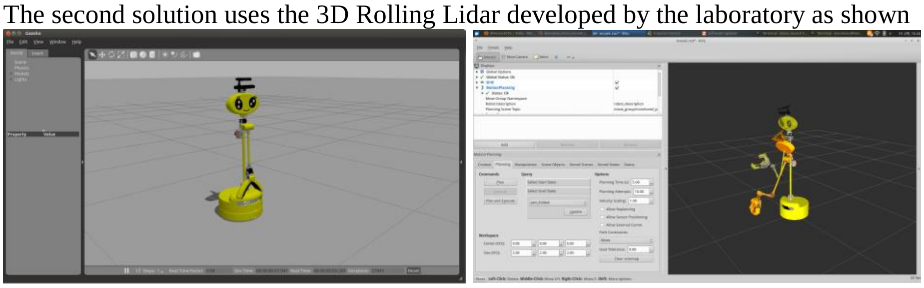
4.1 Kinect V2

The author is proposing two solutions. First solution uses the Kinect V2, the ability is detecting 30 [mm] difference in the range of 0.8 [m] from the wheelchair. Down-sampling, removing outlier, smoothing, detection of a plane, and removal of the plane are used for processing the point cloud data from the sensor. Fig.7 shows the result of detection of 30 [mm] difference in level under a high-illuminance (mostly sunny: 95000[lx]) environment. The Kinect V2 can be used in an outdoor environment.

This method is tested in the Tsukuba Challenge 2015 [7], and its effectiveness has been proved in the real world.

4.1 The Rolling 3D Lidar

The second solution uses the 3D Rolling Lidar developed by the laboratory as shown



(a) Gazebo URDF model (b) MoveIt!

Fig.6. The Happy Mini Simulator

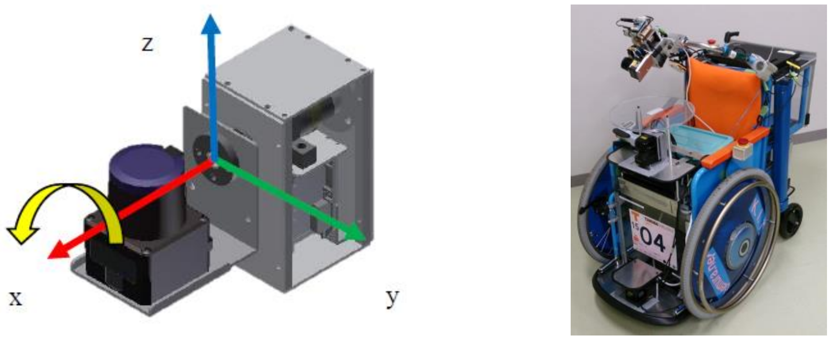
in Fig.8, the ability is detecting 25 [mm] difference in the range of 2.0 [m] as shown in Fig.9. The algorithm uses RANSAC and the DoN (Difference of Normal) method [8] for processing the data.

The author plans to develop the sensor for a commercial electric wheelchair to prevent the falling accident for elderly. This technology could solve one of problems of an aging society in Japan, in addition, the technology is also crucial for an autonomous human support robot.

5 Conclusion

This paper has described the main features of the Happy Mini that is designed with

Fig.7. The results of detection of 30 [mm] difference in level by the Kinect V2.



(a) CAD drawing (b) The autonomous wheelchair

Fig.8. The Rolling 3D Lidar

Fig.9. The results of detection of 25 [mm] difference in level by the Rolling 3D Lidar

the goal of taking care of children, elderly, and for persons feel lonely living alone. The design concepts are kawaii, simplicity, safety, and usability. Thus, the robot is suitable for not only research, but also for education.

Our research goal is “Making the World Happy by Making a Kawaii Robot.” We are using the Robocup@Home challenge as a basis for the robot and working toward completing more important tasks for those persons in real-life situations. Developing the small difference level detector for a wheelchair and a mobility scooter for elderly, and applying the technology to a human support robot is our near future work.

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Information

- Name of the team: demura.net
- Contact information: demura@neptune.kanazawa-it.ac.jp
- Website: http://demura.net
- Team members: Kosei Demura, Kensei Demura, Kazuki Nagashima, Koyo Enomoto
- Hardware: 1 DOF head, 4 DOF arm, Kobuki base, Hokuyo Lidar, Intel Real Sense
- Software: ROS, ROS nav2d, Kaldi, OpenCV, Caffe