Happy Robot 2023 Team Description Paper

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Abstract. This document provides a team description for the Happy Robot team that will participate in RoboCup 2023 in Bordeaux, France, as part of the RoboCup@Home Education Challenge. The team, based in the Demura Laboratory and the Yumekobo RoboCup@Home project at Kanazawa Institute of Technology in Japan, is developing a novel small, lightweight, and inexpensive robot that includes open-source applications for easy participation in the Education Challenge. This paper outlines the hardware and software aspects of the robot's development.

1 Introduction

The Happy Robot team, originating from the Demura Laboratory within the Department of Robotics at the Kanazawa Institute of Technology (KIT) in Japan, is focused on developing a novel compact, lightweight, and cost-effective robot specifically designed for the RoboCup@Home Education Challenge.

The team is a collaborative effort between the Demura Laboratory and the Yumekobo RoboCup@Home project. Its members predominantly consist of first- to fourth-year undergraduate students, many of whom have been involved in the Yumekobo project. Established in 1993, the Yumekobo, "Factory of Dreams and Ideas," is a distinctive educational system within KIT. Its primary aim is to foster creativity and character development among students by supporting over a dozen Yumekobo projects. The central objective of the Happy Robot team is to design robots that contribute to human happiness. As shown in Fig.1 and Fig.2, our robots emulate the appearance of a young child, featuring a vibrant yellow color. We believe that a friendly design is essential for home robots, particularly when engaging with the elderly and children.

Since 2015, our robots have been pioneers in this design concept within the RoboCup@Home league. For RoboCup2023, we have been developing a novel small, lightweight, and cost-effective robot as shown in Fig.3 to reduce entry barriers in the Education Challenge. Many of the robots in the Challenge rely on older systems based on ROS1 and the TurtleBot2. To keep up with the latest technology, we have been developing a novel robot based on ROS2 Humble for the software system, the TurtleBot3 Big Wheel [1] for a mobile platform, and the OpenMANIPULATOR-X for an arm, both developed by ROBOTIS Co., Ltd.

The paper proceeds as follows: Section 2 covers the robot hardware, Section 3 details the software, and finally, future work is outlined.

Fig. 1. Happy Mini

Fig. 2. Happy Mimi

Fig. 3. Happy Edu

2 Robot hardware

2.1 Hardware concept

Our robotic systems' design principle is based on the "Kawaii" concept from Japanese, embodying attributes like cuteness and charm. These robots are designed for roles such as childcare providers and companions for the lonely elderly. Incorporating the "Kawaii" aesthetic can foster comfort for target users, making the visually appealing and approachable external design crucial.

2.2 Hardware description

In line with our established design concept, we have been developing a compact (lenght:230mm, Width:320mm, height:1200mm), lightweight (5.15kg), and cost-effective robot (under $4000), as shown in Fig.3, specifically for the Education Challenge. The robotic platform is based on the TURTLEBOT3 Big Wheel, a low-cost mobile research platform tailored for educational and research applications. Its body is constructed from carbon pipe material, while the 5 DOF arm is made using OpenMANIPULATOR-X. The robot is equipped with various sensors, including an RGB-D sensor (Realsense, Intel), LiDAR (LDS-01, ROBOTIS), and a microphone (VideoMic GO, RODE). A laptop PC serves as the primary computing system for the robot.

Lastly, this section describes human interface of the robot. Human interface is very important for home robots. The robot's interface features an LED matrix array, as depicted in Fig.5, which displays the robot's internal state and other relevant information while maintaining a user-friendly appearance. Fig.5 displays the LED array, which is composed of 280 full-color LEDs organized in 14 rows and 20 columns, with an Arduino UNO controlling it using the NeoPixel library.

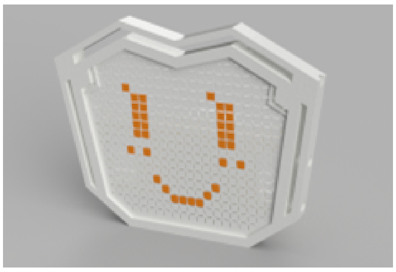

Fig. 4. Human interface

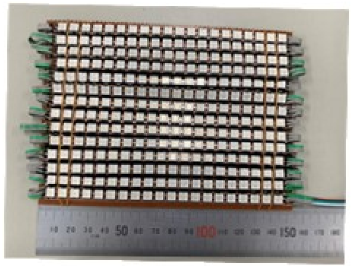

Fig. 5. LED matrix array

3 Robot software

3.1 Software concept

The concepts of software are as follows.

Scratch development: Developing software from scratch without using existing packages in order to improve students' skills as much as possible.

Lightweight computing: Utilizing simple and efficient method without relying on deep learning as much as possible. That reduces the entry barrier for the Challenge, we aim to use affordable CPU-only PCs rather than costly laptops with NVIDIA GPUs.

State-of-the-art: Using the state-of-the-art software system such as ROS2 and Docker will speed up development and enhance students' technical skills.

3.2 Software description

Object recognition: YOLO, a real-time object detection library based on deep learning, is employed for object detection. This library facilitates recognition by automatically generating and training datasets based on objects.

Speech recognition: The Cloud Speech-to-Text API from the Google Cloud Platform (GCP) will be utilized for speech recognition. This API extracts essential commands from the text data derived from the recognized voice.

Navigation: The hardware configuration incorporates the TURTLEBOT3 Big Wheel and the LDS-01 LiDAR, navigated using the TURTLEBOT3 navigation package. Navigation is achieved through AMCL self-position estimation, in conjunction with maps generated by SLAM.

Manipulation: Inverse kinematics are employed for manipulation, determining the angle of each arm joint by specifying the target hand position. The manipulation software relies on a custom-developed manipulation package created by the team.

Bag grasping algorithm: We have been developing a fast and robust bag grasping algorithm that can be processed only by CPU for the Carry My Luggage task. The algorithm consists of the following steps using the LiDAR, and the experimental environment and results are shown in Fig.6 and Fig.7.

Fig. 6. Experimental environment

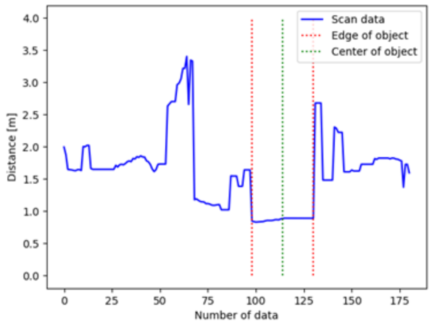

Fig. 7. Back detection result

1. **Bag detection:** Bag detection involves acquiring LiDAR data, extracting the necessary data range, and expanding the data while comparing variance values.
2. **Bag position estimation:** The bag's position is estimated using the intersection value of "Scan data" and "Center of object," LiDAR distance data, and calculated azimuth angle of the bag.
3. **Robot movement to the bag's front:** The robot moves to the front of the bag based on the distance and angle obtained in step 2.
4. **Bag position re-estimation:** The bag's position is re-estimated when the robot is closer to it, and the robot's rotational control is achieved using PID control based on odometry values.
5. **Bag grasping:** The bag is grasped using a fixed hand position, as accurate recognition of the bag handle's position is still under development.

4 Conclusions

The Happy Robot team has been developing a novel small, lightweight, and inexpensive robot for easy entry into the Education Challenge. Our contribution to the Challenge is to evaluate the robot at RoboCup2023, and we will release the hardware and software of the robot as open source on our GitHub [2] to make it easier for beginners to develop their own robots. Our goal is to make the robot the de facto standard of the RoboCup@Home Education Challenge and to spread it around the world.

References

1. ROBOTIS-JAPAN-GIT, `https://github.com/ROBOTIS-JAPAN-GIT/turtlebot3_jp_custom`
2. Demura Laboratory GitHub, `https://github.com/demulab`