KameRider @Home 2016 Team Description

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Abstract. This document is the team description paper of the team KameRider for the participation of RoboCup @Home league in RoboCup 2016 Leipzig, Germany. Team KameRider is a collaborative effort that aims to develop an open robot platform for service robotics. This paper describes the motivation of this effort, the hardware and software of the robot developments, and the scientific contribution and social impacts of our work via a new educational initiative of RoboCup @Home Education.

1 Introduction

Team KameRider is a collaborative effort that aims to develop an open source robot platform for service robotics. Started from 2013, the very limited development resources and manpower team condition had urged a strong motivation to develop a more affordable yet functional solution to take part in RoboCup @Home league and service robot development.

The current team objectives are as follows:

A. Utilize open source solutions for both hardware and software to develop an open source robot platform that is affordable (low cost) and with large community support.
B. Participate in RoboCup @Home to benchmark the open source robot platform performance.
C. Support a new educational initiative of RoboCup @Home Education.

2 Background and Motivation

2.1 The challenges of RoboCup @Home

Starting from 2006, RoboCup @Home [1] has been the largest international annual competition for autonomous service robots as part of the RoboCup initiative. The challenge consists of a set of benchmark tests to evaluate the robots' abilities and performance in a realistic non-standardized home environment setting [2]. It has greatly fostered artificial intelligence development in various domains including human-robot interaction, navigation and mapping in dynamic environments, computer vision, object recognition and manipulation, and many more developments on robot intelligence.

However, it is observed that the development curve of the RoboCup @Home teams have a very steep start. The amount of technical knowledge and resources (both manpower and cost) required to start a new team has made the event exclusive to only established research organizations. For instance, in domestic RoboCup Japan Open challenge, the participating teams in RoboCup @Home were less than 10 teams and similar teams ever since the past few years. There were actually several new team requests but the development gap was too huge for them to even complete the robots.

For this reason, our team had initiated the development of an open source robot platform for RoboCup @Home in 2013. The goal of the project is to develop a basic robot platform to facilitate startup team for the participation in RoboCup @Home. It is developed based on open source solutions for both hardware and software developments for low cost and large community support to facilitate startup of the novice teams. The first working prototype (Fig. 1) had participated in RoboCup Japan Open 2014 and had the honor to receive the *Japanese Society for Artificial Intelligence (JSAI) Award*. Along with the development, we are honored to obtain support from RoboCup Japan Committee and RoboCup Federation, and bonded collaborations with Nankai University (China), Universiti Teknologi Malaysia (Malaysia) and Shibaura Institute of Technology (Japan).

Fig. 1. The first working prototype of the open robot platform for RoboCup @Home

3 Robot Developments

3.1 Open source robot platform development

The open robot platform has a current basic robot hardware configuration (Fig. 2) for fundamental robot platform and add-on modular component systems for customized applications. For example in Fig. 3, a manipulator system (with top vision) and an extended top vision system are added to the hardware configurations during RoboCup Japan Open 2015 for the applications in *Restaurant* task and *Follow Me* task.

3.2 TutleBot as the basic robot hardware platform

TurtleBot[1] is a low cost (basic kit is approximately USD 1,000), personal robot kit with close integration to popular open source software, ROS[2] (Robot Operating System) [3]. The open source robot kit is adapted as the basic mobile platform for this development. The vertical range of the mobile manipulation can be adjusted with an elevated arm with linear motor, a secondary vision system is paired with the robotic arm for object recognition in the manipulation tasks, and 3D printed parts for component systems. An interactive interface with speech and facial expressions is in development for human-robot interaction. A general laptop PC (currently working on a single board computer system) with speakers and microphone is served as the main robot controller. Fig. 2 illustrates a basic robot hardware configuration for this development, and Fig. 3 shows add-on modular component systems, e.g. a manipulator system (with top vision) and an extended top vision system are added to the hardware configurations during RoboCup Japan Open 2015 and RoboCup 2015 Hefei.

3.3 ROS as the robot software framework

ROS (Robot Operating System) is an open source robot software framework with a large community to provide huge collection of robotic tools and libraries. With ROS as the fundamental software framework, this work will adapt and assemble ROS packages and stacks to realize the navigation, manipulation, vision and speech functions of the robot in order to perform the tasks in RoboCup @Home.

Navigation. With the Kobuki[3] and MS Kinect sensor as the mobile base hardware configuration, the TurtleBot navigation package[4] is used for robot navigation with map building using gmapping and localization with amcl, while running the navigation stack in ROS. With the prebuild map and predefined waypoint locations, we can then instruct the robot to travel to a specific goal location with path planning using actionlib[5].

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[1] http://www.turtlebot.com/
[2] http://www.ros.org/
[3] http://kobuki.yujinrobot.com/home-en/
[4] http://wiki.ros.org/turtlebot_navigation/
[5] http://wiki.ros.org/navigation/Tutorials/SendingSimpleGoals

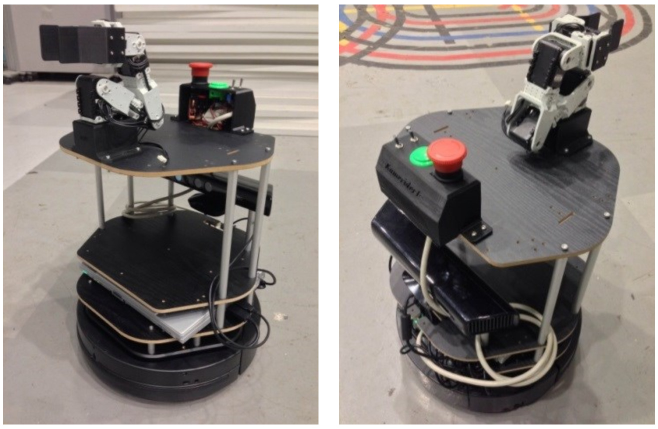

Fig. 2. The current basic robot hardware configuration

Fig. 3. Two hardware configurations during RoboCup Japan Open 2015 (left) and RoboCup 2015 Hefei (right)

Manipulation. We are using TurtleBot Arm[6] for object manipulation (Fig. 4). It consists of 5 Dynamixel AX-12A servo motors, controlled by an ArbotiX-M controller board/USB2Dynamixel. While effort to integrate with MoveIt! is still in progress, we have integrated the arm control with object detection by color detection[7] and object recognition by image processing for object manipulation. Once we recognized the object, we perform object localization by 3D point cloud to obtain the position of the object and calculate the inverse kinematic to make the movement of the arm to grasp the object.

Elevated Arm. An elevated arm (Fig. 5) is developed for flexible height manipulation. The current design is target to enable object manipulation at the height ranges from 0.3m to 1.8m.

Vision. A second vision system (Fig. 6) is built on top of robot with MS Kinect for people/object detection and recognition. The people tracking package is used to track people in the *Follow Me* task.

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[6] http://wiki.ros.org/turtlebot_arm

[7] http://wiki.ros.org/cmvision

Speech. For human voice interaction, we use CMU Pocket Sphinx speech recognizer[8] as our robot speech recognizer. It uses gstreamer to automatically split the incoming audio into utterances to be recognized, and offers services to start and stop recognition. The recognizer requires a language model and dictionary file, which can be automatically built from a corpus of sentences. For text-to-speech (TTS), we are using the CMU Festival system together with the ROS sound_play package.

Apart from human voice interaction, we have also tested sound source localization using HARK[9] for possible people search when the person is outside of the robot visual perception area.

Iconic robot facial expression system. An iconic robot facial expression system as shown in Fig. 1 is under development. The iconic design is simple (low computing power requirement) yet expressive to create the character of the robot with more human-like expressions.

Fig. 4. Robot arm for object manipulation

Fig. 5. Elevated arm for flexible height manipulation

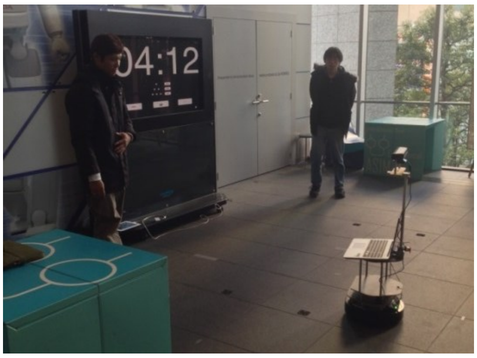

Fig. 6. Vision system on top of the robot

[8] http://wiki.ros.org/pocketsphinx
[9] http://www.hark.jp/wiki.cgi?page=HARK-ROS-TURTLEBOT

4 Scientific Contribution and Social Impacts

4.1 Open source robot platform for service robotics

This work aims to utilize open source solutions for both hardware and software to develop an open source robot platform for service robot research and development. The developed robot platform is open sourced with support wiki, source codes on GitHub and 3D printing parts to ensure easy reproducibility, to build up a community-driven development effort for service robots.

- Support wiki: **http://openbotics.org/kamerider/**
- Source codes (GitHub): **https://github.com/kamerider/**
- Demo videos (YouTube): **https://www.youtube.com/user/kameriderteam**

4.2 Participation in RoboCup 2015 Hefei, China to benchmark the open source robot platform performance

On July 2015, we had participated for the first time in international RoboCup @Home in RoboCup 2015 Hefei, China with the open source robot platform (Fig. 7). With the overall ranked 7th result, it has proven the potential of the developed open source robot platform in RoboCup @Home application.

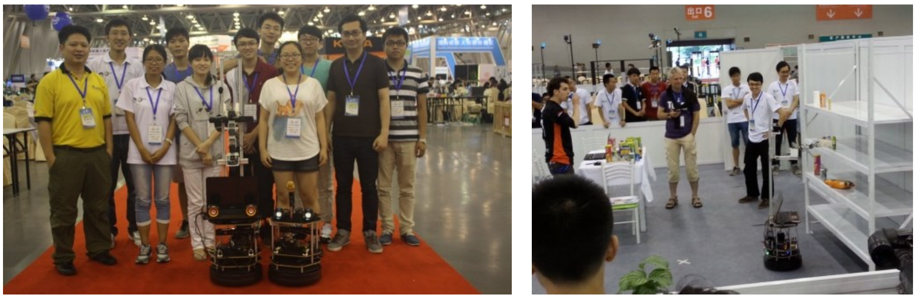

Fig. 7. RoboCup @Home during RoboCup 2015 Hefei, China
Team KameRider is proud to be able to participate for the first time and ranked 7th overall with the open source robot platform

4.3 Support a new educational initiative of RoboCup @Home Education

Along with the project development, a series of related workshops (Fig. 8) and challenges, the Intelligent Home Robotics Challenge 2014 and 2015 (Fig. 9) were organized in Japan, involving the developed open source robot platform.

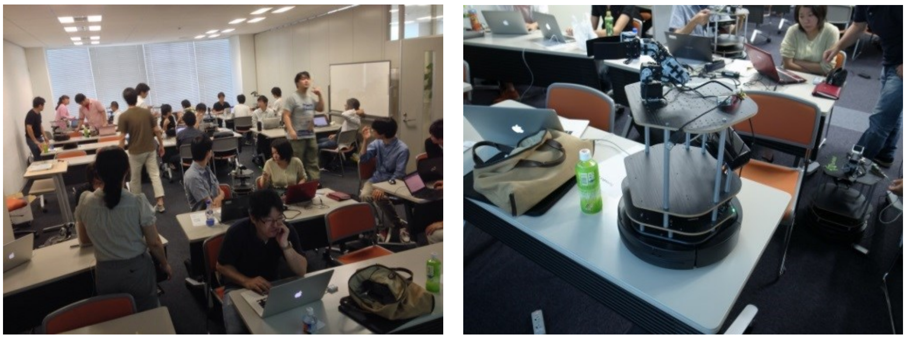

Fig. 8. Workshop hosted by Family & Robotics

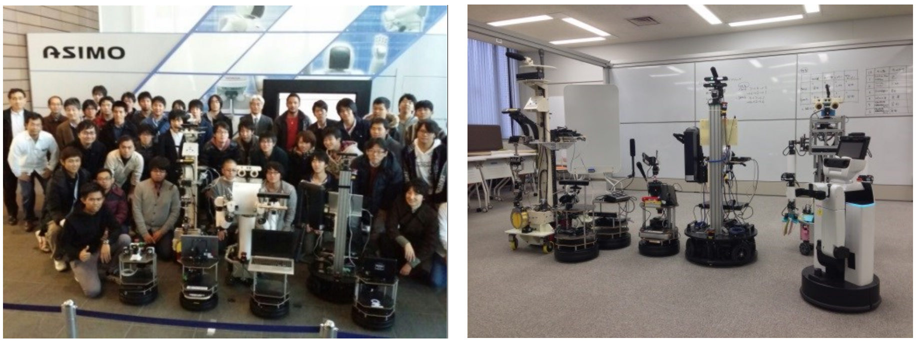

Fig. 9. Intelligent Home Robotics Challenge 2014 (left) and 2015 (right)
Team KameRider is proud to be the winner of Mobile Robot Category 3rd Place and Overall 3rd Place in the Intelligent Home Robotics Challenge 2014 with the open robot platform

A RoboCup @Home demo challenge (SPL Beta 2015) using the open source robot platform was organized in RoboCup Japan Open 2015 on May 2015 at Fukui, Japan (Fig. 10). A local organizing committee was setup within the RoboCup @Home Japan Committee for the organization of the competition. Four tasks from RoboCup @Home rulebook of 2014, i.e. *Basic Functionalities*, *Follow Me*, *Restaurant*, and *Open Challenge* were selected for the demo challenge. Six teams had participated in the challenge with encouraging performance.

Due to the great success of the SPL Beta demo challenge in RoboCup Japan Open 2015 and related developments (workshop and open source robot platform), RoboCup @Home Japan Committee has decided to promote this effort into a new direction: RoboCup @Home Education (http://www.robocupathomeedu.org/), an educational initiative in RoboCup @Home that promotes educational efforts to boost RoboCup @Home participation and service robot development.

A new RoboCup @Home Education challenge is added in RoboCup Japan Open 2016 with 10 teams in pre-registration currently. Two workshops are also scheduled on January and February of 2016 to promote and support new participations. Several outreach programs are taking place to promote RoboCup @Home Education via local workshops and international exchange programs.

Fig. 10. RoboCup @Home SPL Beta demo challenge during RoboCup Japan Open 2015 Team KameRider is proud to be the 1st place winner of the demo challenge with the open source robot platform

5 Team Members

Team KameRider is a collaborative effort with the current collaboration members as follows:

- Team Leader: Jeffrey Too Chuan Tan (The University of Tokyo, Japan)
- Supervisors: Feng Duan (Nankai University, China), Hairi bin Zamzuri, Mohd Azizi bin Abdul Rahman, Zool Hilmi bin Ismail, Cheng Siong Lim (Universiti Teknologi Malaysia, Malaysia), Yutaka Uchimura and Tamio Arai (Shibaura Institute of Technology, Japan)
- Students: Zhendong Luo, Shuning Han, Xiaotang Du, Hongyuan Yu, Zihao An, Chengguang Xu, Fengting Li, Yanmei Jiao, Yuanyuan Tong, Jingtao Guan (Nankai University, China), Mohd Hilmi bin Zakaria, Nurul Ateqah binti Kamarudin, Abdul Hakim bin Sahidi, Wan Mohammad Azmin bin Wan Ruslan, Mohammad Syazwan bin Azhar, Siu Fong Tan, Muhammad Hasif bin Yusoff, Ahmad Muaz bin Abd Muttalib, Hong Yeu Yap, Hanis Sofea binti Azman, Nicole Lei May Tham (Universiti Teknologi Malaysia, Malaysia), Makoto Hinata (Shibaura Institute of Technology, Japan)

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[3] Quigley, Morgan, Ken Conley, Brian Gerkey, Josh Faust, Tully Foote, Jeremy Leibs, Rob Wheeler, and Andrew Y. Ng. "ROS: an open-source Robot Operating System." In *ICRA workshop on open source software,* vol. 3, no. 3.2, 2009.