

# Sun - RoboCup@Home 2013 Team Description Paper

Zhang Qizhi, Zhou Yali, Xu Xinxin, Lv Ye and Zhang Jun

School of Automation, Beijing Information Science & Technology University

zqzbim@{bistu.edu.cn, yahoo.com.cn}  
<http://zt.bistu.edu.cn/RoboCupAtHome/>

**Abstract.** The paper describes the Sun team and presents the approach and novel scientific achievements embodied in our 2013 RoboCup@Home team. Our team builds on School of Automation, our previous team participated in the Robocup China Open competition Humanoid and middle size leagues in 2009 and 2010. Since 2011, we are focused on service robot research, and participated in the 2011 Robocup China Open competition @Home leagues. We have designed and implemented a new robot (including hardware and software) for 2013 international RoboCup@Home. In the team description paper, we will introduce the most relevant components of our current system and the changes we have made to make our system more robust.

**Keywords:** SLAM, Service robot, RoboCup@Home, Object recognition.

## 1 Introduction

The Sun team consists of researchers from School of Automation, Beijing Information Science & Technology University. The team consists of a group of bachelor and master students, advised by two professors and two engineering. The students are participating in the robot design through the bachelor program in robotics, by doing a graduation project in the robot control and computing vision. Our team has participated in three of the leagues under the RoboCup umbrella: the RoboCup@Home league in 2011, the RoboCup Humanoid and RoboCup middle size leagues since 2009 (all in the Robocup China Open competition). Our team clinched 2th place in two individual competitions in Robocup China Open Competitions 2011 and clinched 2th place in Open Challenge competitions in the first college student Robot competitions of Beijing 2012. Our research team has developed the service robot platform and algorithms for the RoboCup@Home league in 2013.

Our team builds on the navigation, object recognition and planning capabilities which we have developed as part of our previous efforts in middle size leagues. RoboCup@Home team will also incorporate our recent research results on human tracking, face recognition, scene perception, methods to improve the perception of human behavior and interaction with humans using "natural" language and gesture modes of communication, etc. The following sections describe the key components of our team.

## 2 Robot Platform

The platforms are improved from our middle size robots, the hardware and software are redesigned according to the demands of RoboCup@Home league. Our platform consists of a four wheel mobile platform for moving, a pair of manipulators for object grasping and a lift platform to localize the position of manipulators. A Microsoft Kinect cameras and a UTM-30LX laser scanner are selected as the sensors. The constructed service robot platform is depicted in Figure 1.

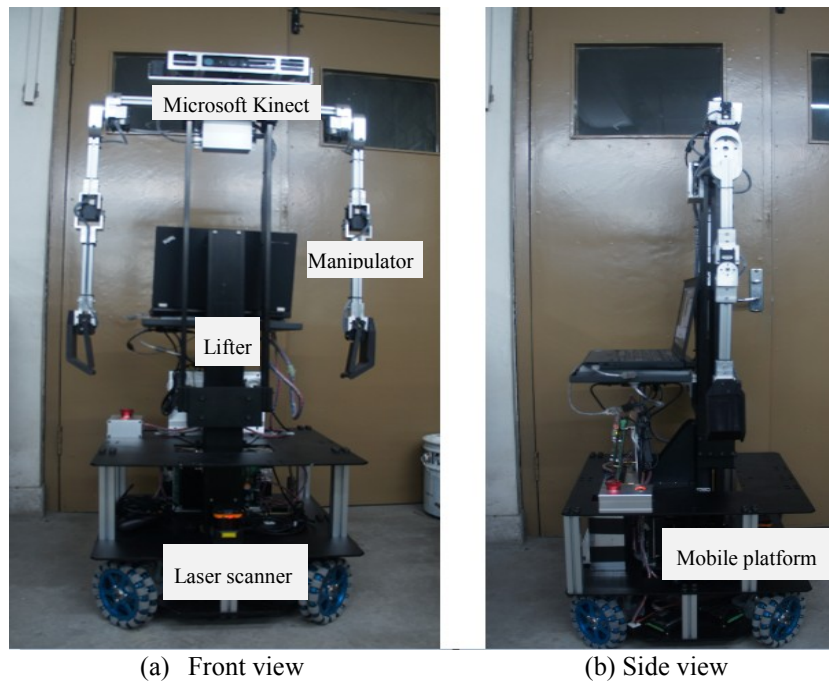
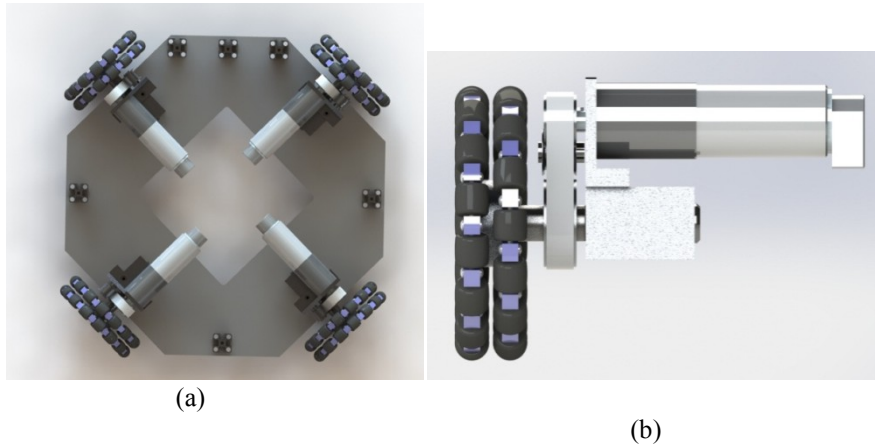


Fig. 1. Robot platform hardware

### 2.1 Mobile platform

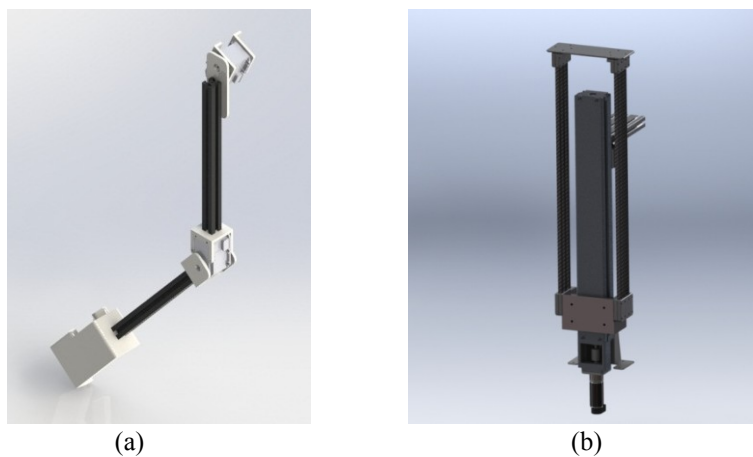
The mobile platform is shown in the bottom of figure 1. The mobile base has four driven omni-wheels which are uniformly distributed on the base. Four maxon RE40 motors are selected to drive the omni-wheels. A synchronous belt transmission is inserted to absorb the shock noise between the wheel and the ground. The designed entity relationship diagrams are shown in figure 2. Our design idea is that the service robot mobile platform should be conveniently moving in a domestic environment, and should be accurate, robust to the input commands. The reason is that reliable motion of the service robot is the backbone of almost all the robot's behaviors.



**Fig. 2.** Render of mobile base (a) and rendering of wheel mounting assembly (b)

## 2.2 Lifting platform and manipulators

Object manipulation is a basic function of the domestic service robot, so the manipulator is necessary equipment for the robot. The 6D industry manipulator need complex inverse kinematics programming, and it is too heavy to apply for the domestic service robot. We design a new 2D manipulator which has a shoulder joint and an elbow joint. The joints are driven by two RX-64 Dynamixel Robot Servo Actuators. Obviously, only using a 2D manipulator, the end-effector cannot reach the entire workspace. We design a drive system which can lift the shoulder joint to appropriate position in the vertical direction and the mobile base can locate the position and direction of the shoulder joint in horizontal plane. The designed entity relationship diagrams of the manipulator and the ball-screw lifting platform are shown in figure 3.



**Fig. 3.** Manipulator (a) and ball-screw drive system (b)

### 2.3 sensors

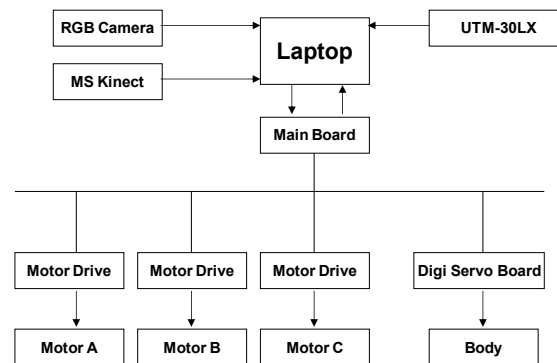
We have used two sensors on the robot platform to perceive its environment:

- A Hokuyo UTM-30LX Laser Range finder has been placed on the mobile base for mapping, location, navigation and obstacle avoidance.
- A 3D Ranging Camera: Microsoft Kinect has been installed on the top of the robot platform for scene perception.

The positions of the sensors are shown on figure 1.

## 3 Software architecture

The software of our robot platform is designed by C++ based on the Microsoft VS2010. The control software architecture is shown in figure 4.

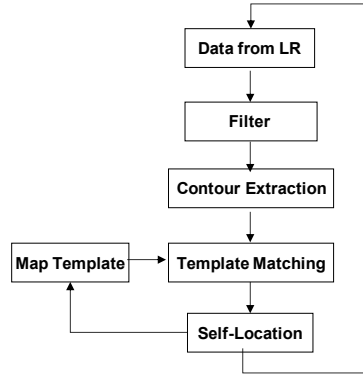


**Fig. 4.** The control software architecture

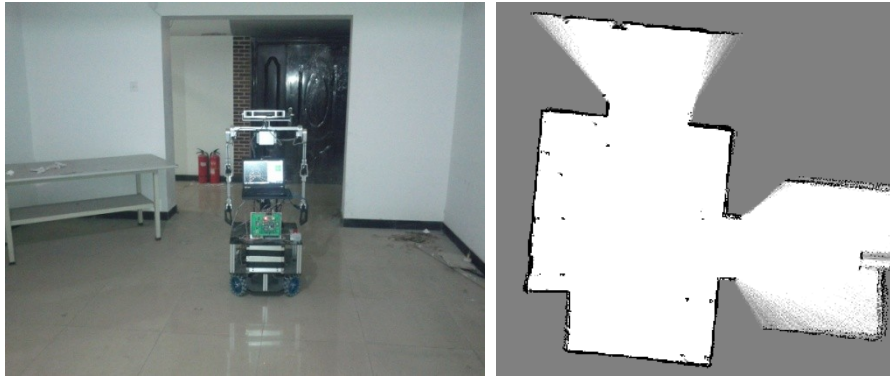
The control software is running on a laptop computer, the sensors input and control output for drive units are all through USB ports. The tasks of the RoboCup@Home are divided into a few subtasks, and every subtask is realized by a functional module.

### 3.1 SLAM

The Slam module is shown in figure 5. Only the data of Laser Range finder is used in our Slam approach, and the odometry is not needed[1]. Scan matching is performed between two laser scans to determine the relative positions from which the scans were obtained. We have implemented the Real-Time Correlative Scan Matching algorithm proposed by Edwin B. Olson[2]. It is robust to initialization error and can find the global maximum of the cost function of scan match. The effect of this method is shown in figure 6, a comparison of the actual lobby environment of our lab to what is mapped by the robot is shown. The bright points represent free region, the black points represent occupy region, and the grey points represent unknown region. There are three tables in the lobby, and the footprints of the table's legs are clear shown in the map. The map is the base of robot location and navigation.



**Fig. 5.** The Slam module



**Fig. 6.** A comparison between real environment and its map

### 3.2 Path planning algorithm

We present a path-planning algorithm for mobile robot platform based on Cellular Automata(CA) and artificial potential field, and the algorithm have been implemented by a 4-layer cellular automata model. Firstly, an expanded occupancy grid map is constructed so that the mobile robot can be simplified as a point in the planning algorithm. Secondly, a digital obstacles artificial potential field map is obtained to include the local influence of the obstacles. Then, a distance propagation map is generated by a CA model. Finally, the optimal collision-free path from start point to goal is extracted by following the minimum valley of the potential hyper-surface. The simulation result is shown as figure 7. The result shows that the optimal collision-free paths can be found by the proposed algorithm. The optimal paths are smooth enough and have larger safety distance from the obstacles. So the optimal paths are convenient to track by our mobile robot platform. Our navigation method can make our robot to track the optimal paths, and in the same time, perform local obstacle avoidance when there are moving objects.



## 6 Conclusion and future work

In this paper, we have introduced our team Sun, and our robot platform for the RoboCup@Home 2013 competition. We have also introduced our robot's ability to grasp unknown objects firmly, to perform SLAM, navigation, and object recognition. Our simplified manipulator can only grasp the object whose axis is in the vertical direction. A new wrist joint will added to perform grasp in arbitrary direction before the RoboCup@Home 2013 competition.



Fig. 8. The extracted table surface and graspable object

## Acknowledgements

We would like to express our sincere thanks for the financial support of projects which are the National Natural Science Foundation of China (11172047) and Funding Project for Academic Human Resources Development in Institutions of Higher Learning under the Jurisdiction of Beijing Municipality (PHR201106131).

Our team video address: [http://v.youku.com/v\\_show/id\\_XNTEwNTA1OTE2.html](http://v.youku.com/v_show/id_XNTEwNTA1OTE2.html)

## References

1. Zhang Qizhi, Zhou yali, A Hierarchical Iterative Closest Point Algorithm for Simultaneous Localization and Mapping of Mobile Robot, Proceedings of the 10th World Congress on Intelligent Control and Automation, Beijing, China, 2012.
2. Edwin B. Olson, Real-Time Correlative Scan Matching, 2009 IEEE International Conference on Robotics and Automation Kobe International Conference Center Kobe, Japan, May 12-17, 2009.
3. Zhang Qizhi, Zhou yali, Scene cognition for object grasping based on kinect, Journal of Beijing Information Science & Technology University, 2012,27(5):11-16
4. Dirk Holz, Stefan Holzer, Radu Bogdan Rusu, and Sven Behnke, Real-Time Plane Segmentation using RGB-D Cameras, In Proceedings of the 15th RoboCup International Symposium, Istanbul, July 2011.