Team Description Paper of MOS2015 From TH-MOS

Xiao Xiang, Wu Yingnan, Yuan Bodi, Ren Wei, Liu Li, Li Zhen, Yin Chengzhen, Mei Bin

Department of Precision Instruments, Tsinghua University, Beijing, China

Abstract. This paper describes the design of the robot "MOS series" and the improvements of robot MOS2015, which is based on MOS2014. The robots are used as a vehicle for humanoid robotics research on multiple areas such as stability and control of dynamic walking, external sensing abilities and behavior control strategies. Compared with last year's robot, the improved robot has changes in both hardware and software,MOS2015 will be used in RoboCup 2015 competitions.

Keywords. RoboCup,Humanoid,Center circle detection, self-localization

1 Introduction

TH-MOS has participated in RoboCup Humanoid League competition since 2006. Last year we combined DARwIn-op software platform with our hardware platform , we improved robot this year in the following research areas.

(1) Structure of the waist and hip joints.

(2) Center circle detection for self-localization.

(3) Dynamic gaits and the software platform.

TH-MOS commit to participate in RoboCup 2015 in Hefei, China and to provide a referee with sufficient knowledge of the rules of the Humanoid League.

2 Hardware and Electronics

A photograph of MOS2015 is shown in Fig 1. The outlook has seldom difference from MOS2014

The whole structure is based on MOS2014,with some improvement on waist and hip joints. Compared with the twenty-one DOF MOS2014, MOS2015 only has twenty DOF: six in each leg, three in each arm, two in the neck.We canceled the one in the waist, and improved the structure of the hip joints, so that the robot can also perform well when kicking getting up from a fall. Canceling the DOF on waist enhanced the structural strength, and avoided the risk of waist breaking off . Besides DOF configuration,this year, the parameters of different parts such as leg length and ankle height are also improved by simulation with gait generating algorithms to ensure better walking stability.

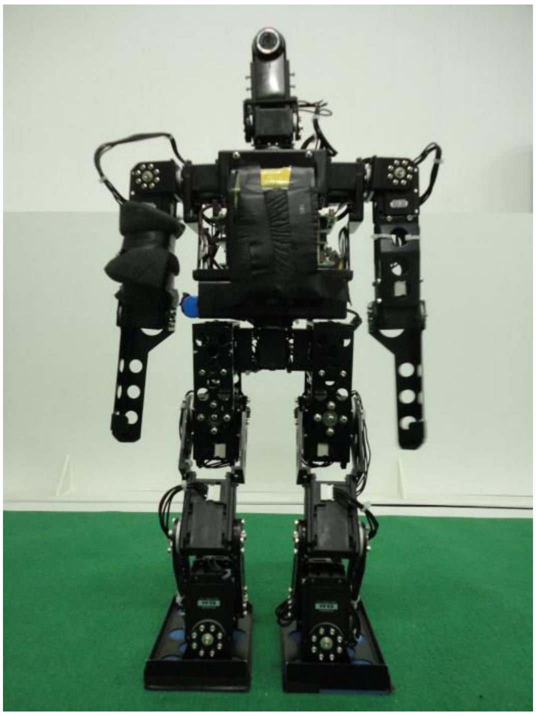

Fig. 1. Humanoid robot MOS2015

The electronic system of the robot provides power distribution, communication buses, computing platform and sensing schemes for the robot. For having a human-like sensation, we use the camera for its vision perception, a 6-axis sensor (connect 2-axis accelerometer, 2-axis gyro and 2-axis digital compass) for dynamic balanced control and servo motors. The architecture of electronic system is shown in figure 2.

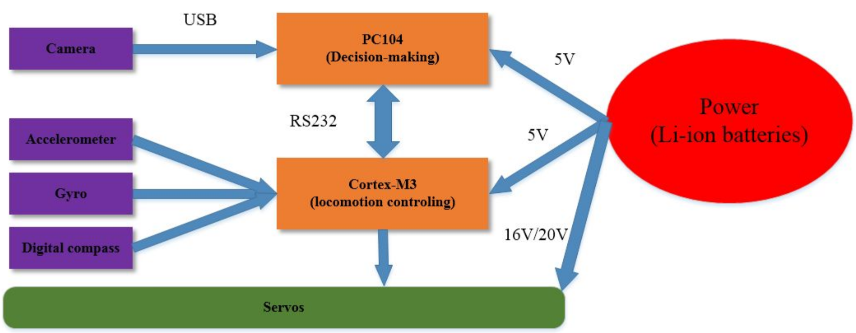

Fig. 2. Electronics architecture for MOS2015

As we can see, the electrical system is the same with former robots, we are considering to update it to a higher platform with more extended port and better performance , the structure of the system shall be remain.

3 Software and Algorithms

Last year we transplanted DARwIn-op's algorithms into our former software platform. We found a lot of bugs of the transplant this year and constantly debugged them. We re-modified the port between software and hardware, and used a new algorithms based on DARwIn-op. The new algorithms is aimed at the difference of electronic system between DARwin-op and MOS2014 , but the main structure does not vary a lot from last year. The software architecture is still composed of two layers. The first layer receives and processes messages from WLAN (used for team communication), digital compass, camera and joint position sensors. The second layer determines the behavior of the robot using results computed in the first layer and the directions from the controller box.

In the algorithm, we use a finite state machine named Motion FSM to handle all low level body movements such as: standing up, walking, key frame motion, detecting fall, automatic stand up. The basic motion FSM is shown in figure 3.Head FSM includes looking around to find the ball and tracking the ball if it is found. Body FSM includes searching the area until the ball is found, approaching the ball until the ball is close enough to kick, and kicking the ball. Figure 4 is body FSM and head FSM.

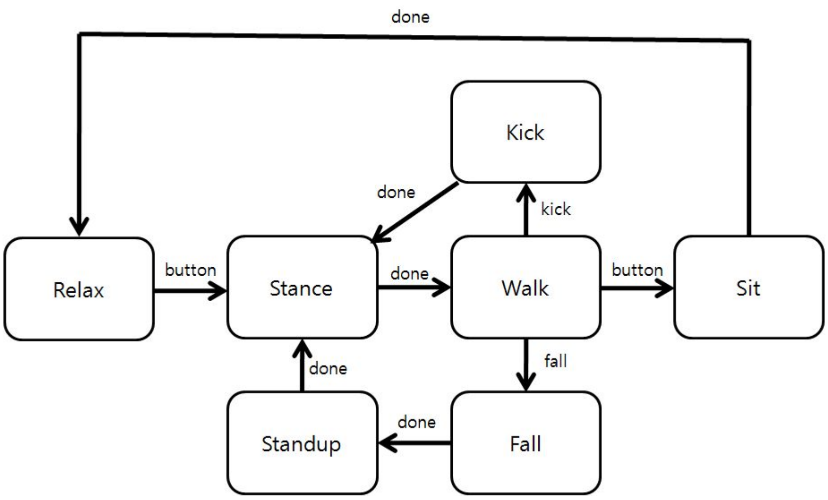

Fig.3 Basic Motion FSM

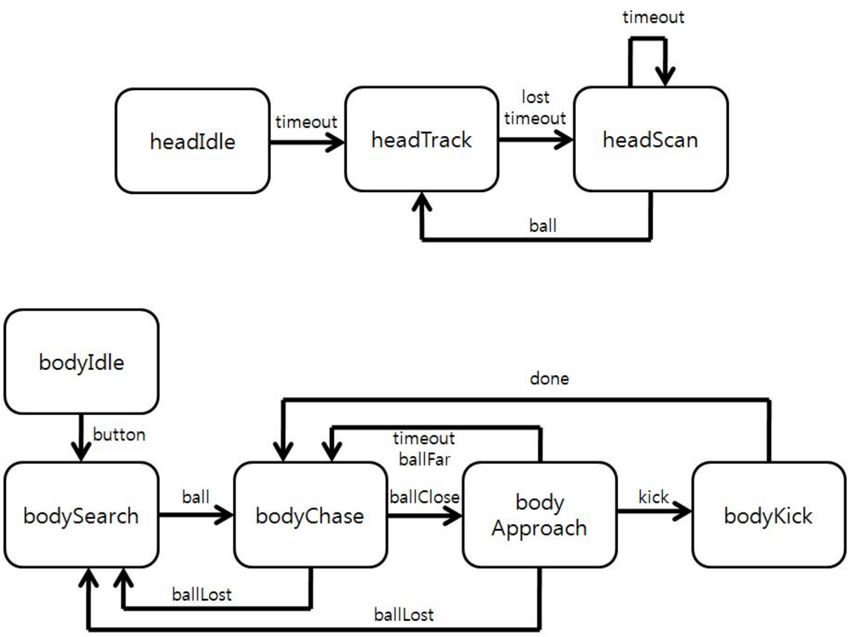

Fig.4 Body FSM and Head FSM

3.1 Omnidirectional Walking

The gait of most bipedal robots is controlled by precomputed trajectories, however, in robot soccer, a dynamic environment forces the robot to adapt their walking direction, speed and rotation to the changes [1]. A robot has to approach any point and module himself toward a preferred direction while avoid any collapse with obstacles on path. Based on predefined walking styles, complex path planning algorithm is needed. The generated series of gait can be eliminated when surrounding varies to some extent.

Our goal is capsulate the biped robot into an omnidirectional moving platform in the view of the mounted camera on head, and making gait parameterized with 3 pa-rameters: offset in forward and sidle direction and another rotation direction around Z axis.

Several walking strategies have been developed, most of which are based on the Three-Dimensional Linear Inverted Pendulum [2]. Firstly, foot trajectory is directly deduced from the foot planner from the gait command. Second, the center of pressure trajectory is defined based on ZMP discipline. COM trajectory is simply related to that of COP assuming the robot as a three-dimensional linear inverted pendulum [3][4][5]. Third, inverse kinematics generates joint trajectories based on the former foot and COM trajectories. An analysis resolution of inverse kinematics can be derived from the specific hip configuration of MOS 2013, which ensured the 3 joints intersected on a single point. [6] had issued the details of this method.

In our research, multiple formulas describing the trajectories are sampled, normalized, and saved in motion control board, and thus both of trajectory type and gain can be adjusted offline, and leaves joint trajectories generated online. An accelerating and decelerating algorithm is also developed to cope with a sudden change of walking speed command from behavior.

3.2 Vision Processing

Last year, we presented a novel method of line detection to meet the need. Further on ,this year we developed a method for center circle detection.

In a RoboCup match, self-location is important. The central circle can be used to locate robot but there is not standard method yet. Without the center circle detection, as the field is getting bigger ,it is difficult for self-location in some conditions. Due to the geometric distortion, the circle in the camera screen changes into an oval, which makes it difficult to extract and locate the center circle. we use a two-step projection to correct the distortion of pictures and Randomized Hough Transform (RHT) to detect circles in images. Finally, the distance between robots and the center circle can be measured according to the location of the pixel of the center of circle in the image. By lots of experiments, we demonstrate that the method is helpful for robots self-location and suitable for our project.

In some conditions, the robot was too closed to the center circle. Then it will be hard for it to self-locate with lines detection. The line crossed the center circle can be detected, but this information is not enough for self-location. The distorted picture of center circle can be corrected by the above theory. To reduce the computational complexity and memory footprint, the RGB image is transformed to gray image before correction. It is the shape of the central circle that we care about instead of the color, so the transformation makes no difference to the result. Because of the relatively steady environment, execution time of each experiment is around 80ms (50ms for distortion correction and 30ms for circle detection).

The correction results of pictures taken from different angles were tested as below, is the angle between the central axis of the camera and the vertical direction (Figure 5, 6, 7).

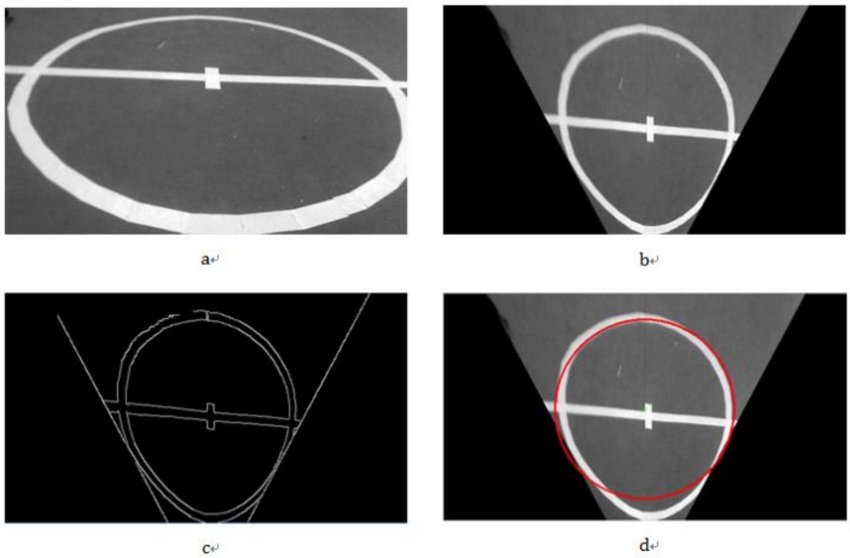

Fig. 5: experiment of $\alpha = 45^o$: (a) original gray image, (b) the image after distortion correction, (c) the image after applying Canny operator, (d) the final result of circle detection

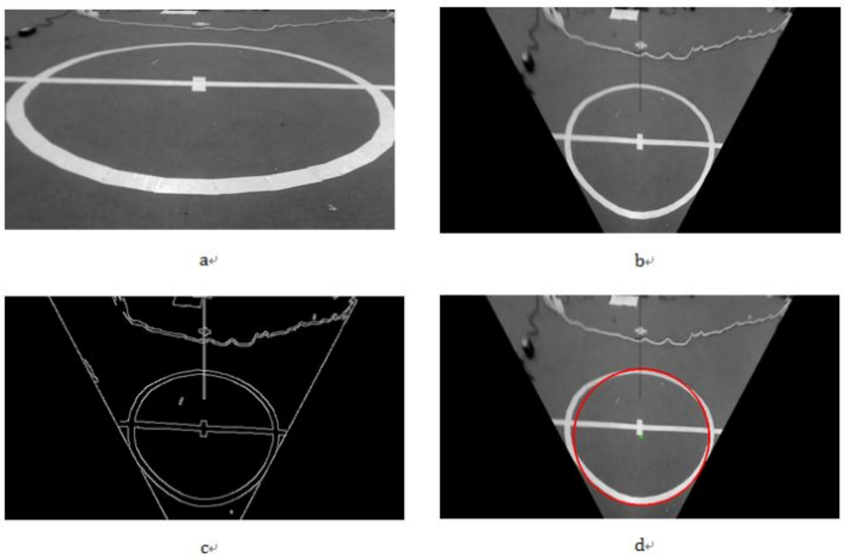

Fig. 6: experiment of $\alpha = 60^o$: (a) original gray image, (b) the image after distortion correction, (c) the image after applying Canny operator, (d) the final result of circle detection

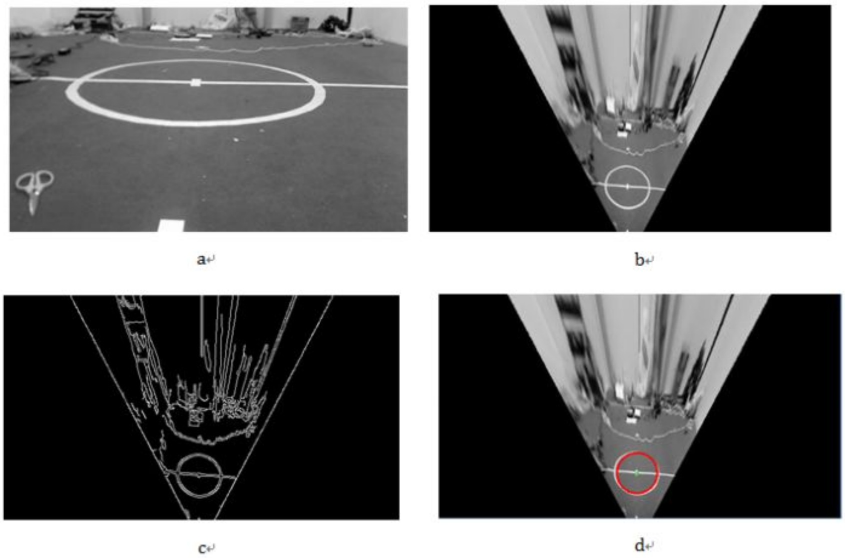

Fig. 7: experiment of $\alpha = 75^o$: (a) original gray image, (b) the image after distortion correction, (c) the image after applying Canny operator, (d) the final result of circle detection

After image processing, the distance between the robot and the center circle can be computed (Table 1). In a Robocup Soccer match, the self-location error under 20% is acceptable and the result in Table 1 shows that our method is helpful for the robot self-location with error less than 10%.

TABLE I: Experiment results

This is a demo table	the real distance (cm)					
	$\alpha = 30^\circ$ (cm)	Error(%)	$\alpha = 30^\circ$ (cm)	Error(%)	$\alpha = 30^\circ$ (cm)	Error(%)
42.4	42.1	0.90	44.4	4.64	45.9	7.50
60.0	58.2	2.93	62.6	4.32	61.6	2.60
67.1	65.6	2.19	70.7	5.37	71.8	6.59
87.9	85.1	3.13	91.5	4.13	92.6	5.12
90.0	87.3	3.06	95.1	5.64	94.3	4.57
94.9	92.4	2.57	101.2	6.70	102.7	7.59
114.2	111.5	2.36	119.4	4.55	125.3	8.85

We have demonstrated a simple and efficient algorithm for the robot self-location based on the center detection. The basic idea of proposed method is first to transform ellipse into circle, and then use RHT algorithm to find the circle. The center circle location is useful for the robot in RoboCup soccer match. The method given in this paper is original and the robot will have a better self-location based on this method. The result shows that this method has an acceptable error. It can solve the problem that robot are not able to locate near the center circle area. We demonstrated it with some practical examples. We hope that this method can be used widely in the RoboCup match and become the basis of the center circle self-location in the future.

3.3 Self-localization

Self-localization is a state estimation problem. The robot needs to estimate its position and orientation from the data of its sensors, mostly camera. We choose the widely used particle filter algorithm to solve this problem. The theoretical foundation is from 'Probabilistic Robotics', [8] and some ideas are from GT2005. [9]

The algorithm of initialization of particles is also important. We design different algorithms for different situation, such as initialization for just stand up, and initialization at the beginning of the match.

If the center circle is found, our robots will locate based on the information the center circle. It is not difficult to compute the distance between the robot and the center the field by using some optical knowledge and geometry skills. Then combined with the magnetic location which can get the information of the direction of robots, we can know the exact position of our robots.

3.4Behavior

The architecture of the algorithms of robot behavior is based on a hierarchical state machine implemented in XABSL [10]. The architecture is composed of a series of options. A simplified option graph of robot behavior is shown in Fig. 7. The main task, which enables the robot to play soccer autonomously, is defined as the root option. The root option is separated into subordinated options until they become basic options, which can be executed by the robot. Those basic options include getting up from a fall, finding the ball, walking and kicking the ball.

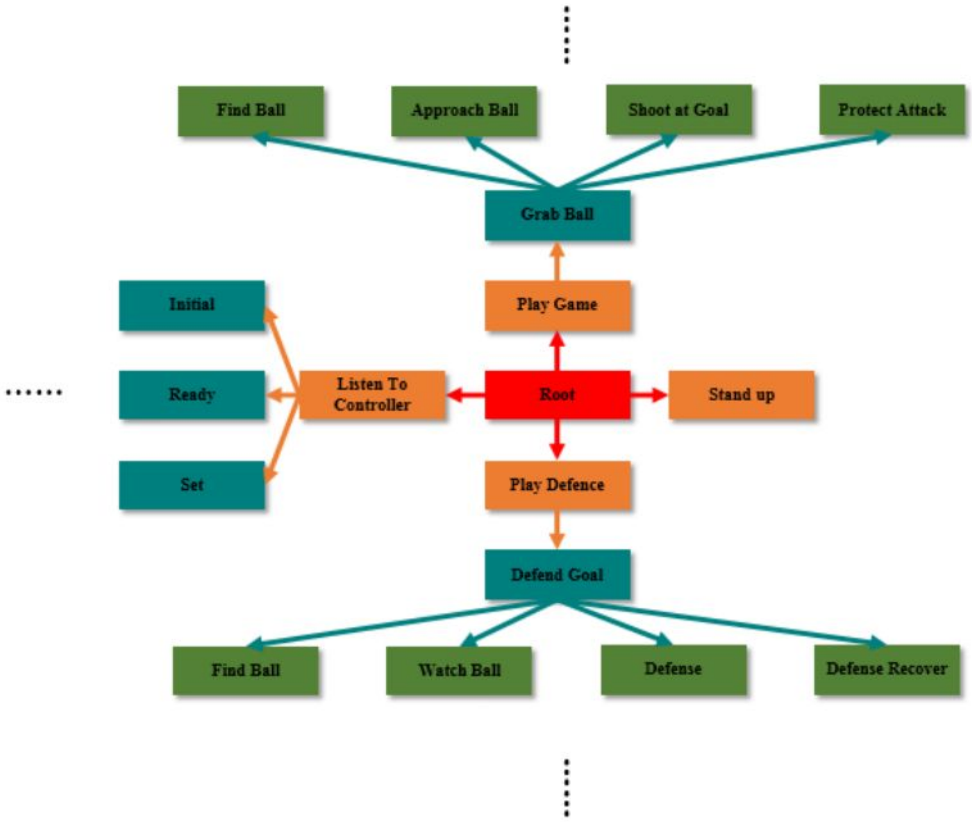

Fig. 7. A simplified option graph of robot behavior

Cooperation between robots is implemented on our robots. First, information such as ball location, robot location and current task of the robot is shared through WLAN. Furthermore, based on shared information, some kinds of team work of soccer are designed. For example, if two robots find the ball simultaneously, the robot that has a better condition in handling the ball will approach the ball while the other one goes another way. However, more complex multi-robots system cooperation is to be further developed on our robot platform.

4 Prior Performance in RoboCup

Team TH-MOS has participated in RoboCup Humanoid League competition since 2006. We are in the top-16 ranking list for 2012/13, and ranking second in technical challenge in 2013. This year , we believe MOS2014 will have a better performance with improved body structure and new algorithms.

5 Conclusion

This paper mainly introduce the details of MOS2014, including its hardware configuration, electronics architecture, software architecture, and difference compared with MOS2013.

References

1. S. Behnke. Online Trajectory Generation for Omnidirectional Biped Walking. Proceedings of the 2006 IEEE International Conference on Robotics and Automation. Florida, 2006, pp. 1597-1603.
2. S. Kajita, F. Kanehiro, K. Kaneko, K. Fujiwara, K. Harada, K. Yokoi, H Hirukawa. Biped Walking Pattern Generation by Using Preview Control of Zero-Moment Point. IEEE International Conference on Robotics and Automation. pp. 1620-1626, 2003.
3. D. Gouaillier, C. Collete, C. Kilner. Omni-directional Closed-loop Walk for NAO, 2010 IEEE-RAS International Conference on Humanoid Robots. Nashville, TN, USA, 2010, pp. 448-454.
4. J. Alcaraz-Jimenez, D. Herrero-Perez, H. Martinez-Barbera. Motion Planning for Omnidirectional Dynamic Gait in Humanoid Soccer Robots. Journal of Physical Agents, 5(1): 25-34. 2011.
5. J. Strom, G. Slavov, E. Shown. Omnidirectional Walking using ZMP and Preview Control for the NAO Humanoid Robot. RoboCup 2009: Robot Soccer World Cup XIII. Springer, 2009, pp. 378-389.
6. C. Graf, A. Hartl, T. Rofer, T. Laue. A Robust Closed-Loop Gait for the Standard Platform League Humanoid. Proceedings of the 4th Workshop on Humanoid Soccer Robots in conjunction with the 2009 IEEE-RAS International Conference on Humanoid Robots. Paris, France, 2009, pp. 30-37.
7. O. Chutatape, Linfeng Guo. A modified Hough transform for line detection and its performance. Pattern Recognition, 32(2): 181-192, 1999.
8. S. Thrun, W. Burgard, D. Fox. Probabilistic Robotics. MIT press, 2005
9. T. Rofer, T. Laue, M. Weber, et al. German Team RoboCup 2005. [Online]. Available: http://www.germanteam.org/GT2005.pdf
10. M. Lotzsch, M. Risler, and M. Jungel. XABSL - a pragmatic approach to behavior engineering. Proceedings of IEEE/RSJ Intl. Conf. of Intelligent Robots and Systems.