

aiRobots Humanoid TeenSize Team Description Paper

RoboCup 2017 Humanoid Robot League, Nagoya, Japan

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Abstract. This paper presents the information of two teen-size robots from team aiRobots, Dept. of Electrical Engineering, National Cheng Kung University, Taiwan, including hardware and software information. Both robot mechanism and intelligent control designs make robot accomplish more difficult tasks like the technical challenge. The control strategies are also developed to achieve the cooperation between two teen-size robots for soccer competition.

1 Introduction

In previous competitions, our team won the second place of the technical challenge in the KidSize Humanoid League in 2010 RoboCup, Singapore, and the 1st place of the technical challenge in the AdultSize Humanoid League in 2013 RoboCup Japan Open, Tokyo. We also participated several other Adult-sized Humanoid League or Kid-sized Humanoid League competitions in HuroCup of FIRA and won many medals, including 1st and 2nd place prizes in humanoid robot competitions. For example:

- 2016 FIRA@Taiwan, HuroCup Category, Adult-sized League: Basketball 1st place, Marathon 1st place, Sprint 2nd place, Weight-Lifting 2nd place, Wall Climbing 2nd place, and All-round 2nd place.
- 2015 FIRA RoboWorld Cup, HuroCup Category, Kid-sized League: Long Jump champion ◦
- 2015 FIRA RoboWorld Cup, HuroCup Category, Adult-sized League: Weight Lifting 1st place, Long Jump 1st place, Sprint 1st place, Basket Ball 1st place, Obstacle Run 1st place, Penalty Kick 1st place, Climbing Wall 2nd place and All-round 1st place.
- 2014 FIRA RoboWorld Cup, HuroCup Category, Kid-sized League: Basketball 1st place.

- 2014 FIRA RoboWorld Cup, HuroCup Category, Adult-sized League: Weight Lifting 1st place, Climbing Wall 1st place, Sprint 2nd place, Basket Ball 2nd place, Obstacle Run 3rd place, Marathon 3rd place, and All-round 1st place.
- 2013 IRC FIRA Invitational Cup, HuroCup Category, Adult-sized League: Sprint 2nd place, Marathon 2nd place, Penalty Kick 1st place, Weight Lifting 1st place, Basketball 1st place, All-round 1st place, and Korea President award.
- RoboCup Japan Open 2013 Tokyo, Adult-sized Humanoid League: 1st place in technical challenge ◦
- 2013 FIRA RoboWorld Cup, HuroCup Category, Adult-sized League: Sprint 2nd place, Weight Lifting 2nd place, Obstacle Run 2nd place, Marathon 2nd place, Penalty Kick 1st place, Basketball 1st place, and All-round 1st place.

2 Robot system description

For 2017 RoboCup teensize soccer game, we design two brand new teen-sized robots. The following information are the basic introduction of our system.

2.1 Robot height and weight

With respect to the previous robot, David Junior shown in Fig. 1(a), the new design robot, David Junior II shown in Fig. 1(b), reduce 35% of robot height and 50% of robot weight which make the new design more compact. The new design also reduces the degree of freedom about 38% with respect to the humanoid robot for HuroCup, which can shoot a ball into a basket and climb a wall.



Fig. 1(a). David Junior



Fig. 1(b). David Junior II

2.2 Soles of the robot feet

Previously, we design soles of the robot feet as a huge plane in order to increase the waking stability of humanoid robot. However, compare with the previous walking control algorithm, the new algorithm is more stable and reliable, so we can design smaller soles to reduce the robot weight and the robot can still walk stably. Recently, to make sure the robot can play soccer on grass, the new design of soles is inspired by track spikes. We add some spikes at the bottom of the soles to reduce the contact area

between the soles and grass. In other words, we leave the hollow area under the soles when it touches the ground.

2.3 Crash-recovery

To ease the damage of collision when robot falls down or crashed by other robots, we design some bumper for the robot in its front and back sides.

2.4 Electromechanical systems

We use PICO880 to deal with the vision processing and communicate with STM32 microcontroller which governs the motion of our servo motors. Also, we use 9-axis IMU and pressure sensors to help the robot obtain enough information while doing tasks.

2.6 Gait Generation

First, to generate a reliable gait, we design the precise control theory for each servo motor based on LIPM [1]. Then we apply MATLAB to generate ".m" files for simulation, and real-time control the robot by STM32 microprocessor.

2.7 Strategy system

PICO880 is the main core in our strategy system. Depending on those data grabbed by visual webcam, the proposed strategy system could determine proper actions at every moment.

3 Gait Pattern Generator Experiment results

The new gait pattern generator [1] with a natural zero moment point (ZMP) reference makes the humanoid robots walk more efficiently. The speed of our teen-sized humanoid robot, David Junior II, is 17.4 cm/s which becomes 2.4 times faster than the past performance of the robot. Based on linear inverted pendulum model (LIPM), users can adjust the parameters of the pace distance, height, yaw angle, pitch angle and so on.

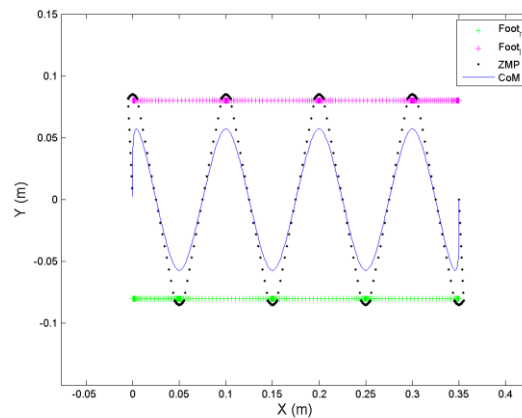


Fig. 2. ZMP reference and center of mass (CoM) trajectory in the XY plane for the second gait pattern [1].

The continuous moving ZMP with the corresponding center of mass (CoM) trajectories derived by LIPM and shown in Fig. 2 can make humanoid robots walk more naturally. Compared to the traditional gait generators fixing ZMP in the sagittal and lateral plane, the higher performance of the control theory in [1] was validated.

The actual ZMP can be measured by the four force sensors on each foot [2] as shown in Fig. 3, the robot can adapt to different environment and uneven terrains with feedback control. Moreover, the Fuzzy Policy Gradient Learning (FPGL) method [3] is applied to the robots for reinforcing the gait pattern shown in Fig. 4. FPGL is an integrated machine learning method based on Policy Gradient Reinforcement Learning (PGRL) and fuzzy logic concept [4]. In the experiment, the planning movement reduces the tilt of the trunk and improves the efficiency of walking.

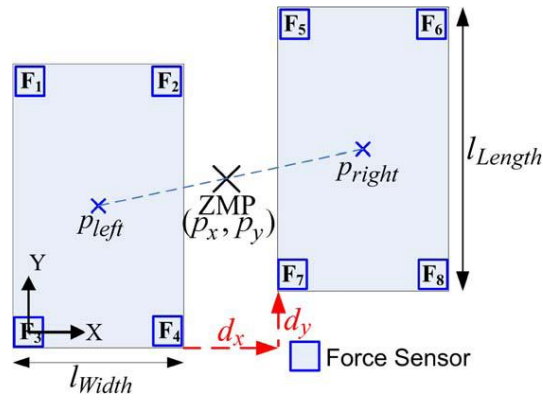


Fig. 3. Actual ZMP diagram of two soles [2].

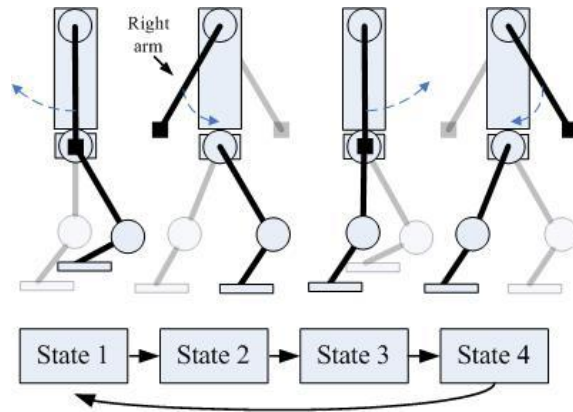


Fig. 4. The swing movement of right arm in the walking cycle [3].

4 Image processing

4.1 Field detection

In the soccer field, it might be a crucial work to detect the line. However, the line is white and similar to many object in the environment. The first step to solve this problem is to remove the background which is above the artificial grass.

And next step is image binarization, which makes pixel similar to the field line to white and make the others to black as shown in Fig. 5. Then one can find out those point that is on the line [5]. And we can consider that these points that are close and has similar slope are on the same line.

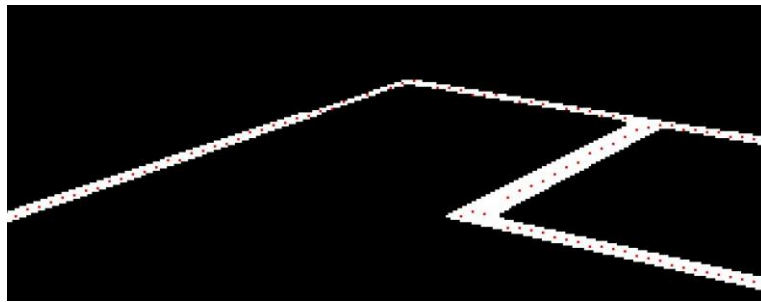


Fig. 5. The result of line detection.

4.2 Ball Detection

It is hard to detect the soccer with color because the color of the object on the field like ball, line and goal are almost the same. Consider that the soccer ball are round and almost white. We use the Circular Hough transform to detect the circle as shown in Fig. 6, and check whether the white pixel inside the circle is enough.

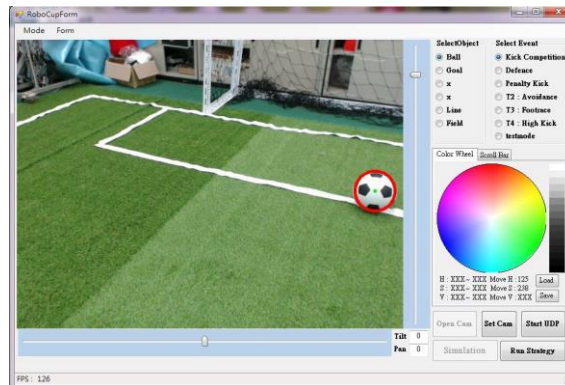


Fig. 6. The result of ball recognition.

4.3 Simple Mean Shift Algorithm

In order to keep tracking the targets, which including the ball, goal, and defending robots, we adopt widely used mean shift algorithm [6]-[8]. This algorithm could search the region of interest and reduce the computational time in processing the real-time image.

5 Soccer strategy

The decision making strategy of our robots can be separated into two categories. The first one is role changing method. Each of our robots has its own position on the field. But sometimes we need to change its role to defense or attack according to the status on the field [9]. For example, when goalkeeper detect the opponent come to our goal, the attacker will change its role into guard to defense cooperatively with goal keeper. This mechanism keep our strategy flexible to response to any situation in the field. The second is the basic behavior of player just like dribbling through opponents. This was done by the cooperation of positioning mechanism, image processing and path planning. After positioning the ball, goal, and opponent, player can decide a path that is shortest and without obstacle to the goal [10].

6 Conclusions

The TDP described our new design humanoid teen-sized robots from the hardware, software, gait pattern generation, image processing, and control point of views. We want to commit here that we will participate in the TeenSize game of the RoboCup 2017 Humanoid League competition, Nagoya, Japan, and make a person with sufficient knowledge of the rules available as referee during the competition.

Team Members

Team leader: Tzoo-Hseng Steve Li

Team members: Li-Fan Wu, Nien-Cu Fang, Chaun-Han Cheng, Ting-Nan Tsai, Chun-Yuan Liu, Chian-Yi Huang, and Lin-Han Chen

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